PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

QUEENSLAND

FOR 1925.

VOL. XXXVII.

ISSUED 23rd JANUARY, 1926.

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Vol. XXXVII. No. 1.

Proceedings of the Royal Society of Queensland.

Presidential Address.

By W. H. BRYAN, M.C., M.Sc., Department of Geology, University of Queensland.

(*Delivered before the Royal Society of Queensland, 30th March,* 1925.)

It is my first sad duty to record the death of two members of this Society, the first of whom died full of years and of honour, while the other was taken in the vigour of early manhood.

Richard Gailey, a life member of this Society, was born in county Donegal, Ireland, in 1834. He was educated with a view to his following the architectural profession, and he established himself in that profession in Londonderry. He left Ireland in 1863, and after spending some time in Melbourne came in the following year to Brisbane. Here he was appointed a licensed surveyor, and in this capacity he visited many parts of Queensland. He surveyed and laid out the town of Bowen, and also designed many buildings in Toowoomba, while in Brisbane are to be seen many examples of his architectural and constructional skill. He was also one of the promoters of the Brisbane Permanent Building and Banking Company and valuator of some of the leading building societies of Brisbane. The loss which this Society feels is shared by the Royal Geographical Society, the Royal National Association, and other institutions of which he was a valued member.

Lance E. Cooling was born in Brisbane in 1893 and died in Townsville at the early age of 31 years. His whole adult life, with the exception of the three years during which he served his country with the Australian Imperial Forces in France, was devoted to the elucidation of problems concerning the health of the community. He first held the position of Health Inspector in Brisbane, much of his time being given in fighting the mosquito pest. After his war service he carried out entomological research with Dr. Ferguson at the Laboratories of Tropical Medicine in Egypt. In 1921 Mr. Cooling left the Department of Public Health to give his services to the Hookworm Campaign and, in company with Dr. Baldwin, conducted mosquito surveys in West Australia and the Northern Territory. In 1922 he was appointed Assistant Entomologist to the Tropical Institute at Townsville and in 1923 was promoted to the position of Entomologist at the same institution. Mr. Cooling wrote many papers and articles of scientific value, some of which are published in the Proceedings of this Society, while many others appear as publications of the Commonwealth of Australia Department of Health. Many of these papers dealt with the mosquito, which Mr. Cooling had studied both from the strictly biological and health points of view. His early death is a severe loss not only to this Society but to Australia.

Although they were not members of this Society, I feel that I cannot pass without mention two other brilliant young scientists whom Australia has lost within the last year. I refer, of course, to Professor Hunter, who lately occupied the Chair of Anatomy at Sydney University, and the late Mr. Evan Stanley, who did such magnificent geological work of a pioneering type in Papua.

With the passing of these three brilliant young scientists Australia has been dealt an untimely blow, but she is left enriched by their memory and example.

* * * * * *

Two events of especial scientific interest have occurred in Australia during the past year.

Professor Sir Edgeworth David, F.R.S., the universally acknowledged and beloved leader of our geological world, has vacated the Chair of Geology at the University of Sydney, and Professor Leo A. Cotton, who has been Acting Professor for the past two years, has been appointed in his place.

The biennial meeting of the Australasian Association for the Advancement of Science was held in Adelaide. An unusual feature was that the meeting was held in the month of August, thus ensuring more pleasant climatic conditions than hitherto, and coinciding with the University vacations. Professor Richards, D.Sc., the Society's representative, has reported that the meeting was highly successful and that among other conclusions reached by the Association was the important one which initiated the formation of a scheme of continuity of membership in the Association.

The report of the Council which has been placed before you shows that the Society can congratulate itself on the completion of a very successful year.

The membership of the Society has increased by more than fifty per cent. during the year, the annual volume of the proceedings which has been issued is one on which members may look with justifiable pride, and the treasurer's statement shows a quite substantial credit balance. This success is largely due to the increased Government subsidy, but is also due in large part to the effort made by the Council, as the result of the verbal assurance given to the Premier of Queensland, that it would endeavour to increase the membership of the Society by the addition of suitable members of the community.

The library of the Society has been considerably improved by the installation of a new and commodious set of book shelves and by the partial rearrangement of the library, undertaken by members of the Council. This rearrangement was discontinued on advice being received from the University of Queensland that new quarters would shortly be allotted to the Royal Society for use as a library on the ground floor of the building in which the University library is now housed. The new position of the Society's library should render it much more accessible to members than that which it at present occupies, and the advantages of close association with the University library are obvious.

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EARTH MOVEMENTS IN QUEENSLAND.

(Figs. 1 to 4.)

I. INTRODUCTORY AND GENERAL.

The great T. H. Huxley in his famous Presidential Address to the Geological Society of London pointed out the necessity for the scientist, equally with the merchant, of a periodic "stock-taking," and I propose with your permission to take stock of the data which have accumulated concerning earth movements in the State of Queensland.

The use of political boundaries as partial limits to the area under consideration is obviously artificial, for in no case does the boundary between Queensland and an adjacent State coincide with a geological break or structural discontinuity, but such use is defended on the grounds of its undoubted convenience. It would, however, be patently absurd to ignore the tectonics of the neighbouring States, consequently conclusions arrived at from a study of the data of earth movements in Queensland will be compared with and checked against those generalisations which are usually accepted in the other States.

New Guinea has purposely been omitted from this study, for both in its structural nature and tectonic history, except in the low-lying southernmost portion, it differs widely from Queensland and must therefore be considered in the main as forming a quite distinct unit. In the words of the late Evan Stanley, who did such magnificent work in Papua :— "The trend lines passing northerly from Australia are lost in the deltas and southern strands of New Guinea"[1] (see also Andrews,[2] Benson[3]).

Any work dealing with the many movements of an extensive area of the earth's crust, and the possible relationship of these movements one to another, may be considered from two distinct points of view, viz., the temporal (historical) and the areal (geographical). In this address the data will be considered primarily from the historical aspect, and secondarily from the geographical aspect. Attempts will be made—

(1) To collect the data bearing on earth movements in Queensland;

(2) To place these data upon maps;

(3) To analyse the data and determine the age of each of the several movements;

(4) To study the areal distribution and intensity of each movement ;

(5) To consider whether the movements either as regards historical sequence or areal distribution can be assigned to one fundamental scheme and whether such scheme be rhythmic in its nature ;

(6) To study the relationship between earth movements and igneous activity.

The chief difficulty in reconstructing the tectonic history of a large area results from the facts that (1) at any given time different portions of the area may be affected by movements of different intensity and along different directions, and (2) any selected small portion of the area may be affected by movements which vary both in intensity and in direction during the passage of geological time. These difficulties are simplified if all the variations, both of direction and intensity in both time and place, are regular, and they are rendered considerably less difficult if either of the factors is constant or varying uniformly, but if the variations in intensity and in direction be irregular, both areally and temporally, the problem becomes impossibly complex.

It is often difficult to read the record of an old formation's movements, for while the present strike should be the resultant of all the different forces to which the formation has been subjected, this is not always apparent. In some instances the results of an older movement have been so indelibly impressed that the formation has been apparently unaffected by a later movement, which has, however, influenced profoundly the trend of the younger rocks in its immediate vicinity. In other cases the latest movements have been so intense as to obliterate all but the most recent portions of the formation's tectonic history.

At first glance the data bearing on earth movements in Queensland appear so incomplete, so confusing, and in many cases so contradictory, that it seems hopeless to search for any simple fundamental plan, and recalling the warning given by Professor Priestley from this chair two years ago[4] one wonders whether there is such a simple fundamental plan underlying such confusion of data. Nevertheless many broad generalisations have been made in the past concerning the tectonics of Australia as a whole, and of Eastern Australia as a structural unit, and such generalisations necessarily include Queensland. These will be considered as opportunity offers.

It must be patent to all that in an address such as this it is impracticable —no matter how advisable—to record every observation of strike, dip, *et cetera*, that has a possible bearing on all the various earth movements to which Queensland has been subjected. Hence the data used in this address are to some extent selected data, in that all the notes and observations used by the writer in his study of the subject have not been included in the text and accompanying illustrations of this address.

A further involuntary selection will also have been in operation through the almost certain failure of the writer to have read and noted every published fact in a field so wide. With regard to the latter, one can but hope that no serious omissions have been made. With regard to the former, the writer realises the grave danger which lies in the deliberate selection of data and the consequent introduction of the personal factor. This is to be deplored, but in the nature of the case can scarcely be avoided.

In the following pages, in order to eliminate personal bias as far as possible, the writer, where practicable, has quoted his authorities literally in preference to paraphrasing their accounts and opinions. The earlier portion of the address which deals with the collection of data is thus made up in large part of extracts from numerous publications dealing directly or indirectly with the earth movements of Queensland. While the writer has, in this portion, offered occasional original comments and criticisms, these are for the most part reserved for the more general treatment of the subject found in the later chapters of this address.

II. PRE-CAMBRIAN AND LOWER PALÆOZOIC EARTH MOVEMENTS.

(A) The Cloncurry Series.

The earliest movement in Queensland of which there is evidence seems to have taken place in Pre-Cambrian times. The existence of Pre-Cambrian formations in this State has long been suspected, but nothing like definite proof of their presence was forthcoming until quite recently, when Mr. E. C. Saint-Smith[5] brought to the notice of the geological world certain fossils which had been collected from the upper portion of the Templeton River, some twelve miles to the west of Mount Isa in the Cloncurry district. The fossils were examined by Mr. W. S. Dun, who concluded that they were closely allied to, if not generically identical with, the trilobites *Olenellus* and *Ptycopharia*, and the brachiopod *Micromitra*. A Lower Cambrian age was thus almost certainly indicated for the series from which the fossils were collected.

A field examination by Saint-Smith showed that the series ". . . may be considered as being practically horizontal, though slight rolls dipping both north-east and south-west at a maximum angle of 10 degrees were observed." The absence of folding or any other sign of disturbance is a remarkable feature not only on account of the great age of the series, but also because less than five miles away is the very extensive, unfossiliferous, closely folded and strongly metamorphosed Cloncurry Series. The most reasonable conclusions in the light of the palæontological and field evidence are—

(1) That the Cloncurry Series is of Pre-Cambrian age,

(2) That the intense folding movement which so disturbed the Cloncurry Series is also of Pre-Cambrian age, and

(3) That the Cloncurry district has been only slightly disturbed by folding movements since Pre-Cambrian times.

The first of these conclusions finds support in the opinions of J. W. Gregory,[6] Woolnough,[7] Jensen,[8] and Saint-Smith,[9] all of which were published before the discovery of the Cambrian Series, although the official view of the Geological Survey of Queensland, based on the discovery of "(?) Silurian" fossils from the Cairns Range (Cloncurry district), was that the Cloncurry Series was of doubtfully Silurian age. That the strata actually containing these fossils is of Silurian age is quite probable, but according to Mr. B. Dunstan[10] they are practically horizontal and unaltered, and in the opinion of the writer can thus scarcely belong to the steeply dipping and highly altered Cloncurry Series. Such an opinion receives support from Mr. L. C. Ball,[11] who wrote in 1908,—"The occurrence of Silurian fossils in the Cairns Range is insufficient evidence for the classifying of the whole district as Silurian."

The Cloncurry Series has been described by Jack, Ball, Cameron, Woolnough, Reid, Jensen, Saint-Smith, and Dunstan. These writers are practically unanimous on the following points. The Cloncurry Series is of great extent (Ball estimates "the schists in North-Western Queensland alone" to cover an area of 400 by 100 miles). The series is of very great thickness (in the neighbourhood of Mount Isa, Dunstan's estimate is "at least 15,000 feet"). The series is highly folded and strongly metamorphosed. Most of the authorities cited also regard the Cloncurry Series as being closely comparable with the Pre-Cambrian schists of the Northern Territory and Western Australia.

On the important point regarding the direction taken by the axes of folding there is, however, some difference of opinion, for Jensen,[12] in 1922, citing Jack, Rands, and Cameron as his authorities, states that "the general strike . . . in the Cloncurry district is east-west, west-south-west, east-south-east," and shows only these trends in his map. (Fig. 2.) That such strikes are to be found in the huge area covered by the Cloncurry Series there is little doubt, but that they represent "the general strike" seems highly improbable in the light of the following statements, some of which were published before and others after the appearance of Jensen's paper.

Cameron[13] in 1901 wrote of the series, "These beds have a very general meridional strike over the whole of the area occupied by them." (This quotation is taken from one of the authorities cited by Jensen in support of his contention.)

Ball[14] in 1908 described the slates in the area as striking from N. 20° E. to N. 20° W.

Dunstan[15] in 1920 states of the series, "All the sedimentary rocks are severely contorted, the axes of the folds of which are generally in a north and south direction, with very little subsequent movement having taken place to disturb the uniformity of their folds." Further "These [among other] geological features apply to the whole of the Cloncurry Series, the length of which is 400 miles, the width from 25 to 100 miles averaging 40 miles."

Reid[16] in 1921, writing of that portion of the area in the vicinity of Selwyn, stated that schists of the Cloncurry Series strike N. 5° W.

Dunstan[17] in 1924, in describing the Mount Isa silver-lead field, wrote—" The general strike of the Cloncurry Series is N.N.W. . . ." and again in the same report,—" undoubtedly a great tectonic movement has taken place in the Cloncurry Series along a generally N.N.W.-S.S.E. strike." Saint-Smith in the same year speaks of " a consistent westerly dip of the strata over a minimum width of 3 miles" at Mount Isa.

In the light of all this evidence the writer feels that not only are the easterly strikes less important than the northerly, but that they are so insignificant that to place them upon the map in a work such as this would be misleading, even though the northerly strikes were also represented on the map.

Mr. Dunstan has lately made a special study of the Cloncurry Series at the Mount Isa silver-lead field, where " undoubtedly a great tectonic movement has taken place in the Cloncurry Series along a generally north-north-west strike." He divides Mount Isa into " a central disturbed zone," flanked to the east and west by " undisturbed but steeply dipping sediments." " The central zone has been produced by movement in the strata within this zone, but the pressure producing the movement has been or is acting along the highly inclined bedding planes. Probably the first movements were in the disturbed area, in which they have been obliterated in the general crush, but the contact of this zone with the regularly bedded strata on its flanks is very marked. The faulting on the east and west, in being along the regular lines of stratification, is not pronounced, although probably very severe." " In addition to the disturbance that produced the central contorted zone, a number of well-defined faults striking N.N.W. or E.-W. has been observed. These are usually normal, and the beds have been thrown westerly on the northern side of the dislocation. In the central disturbed zone there are faults, foldings, contortions, and crushed masses." " The great width of disturbed country diminishes very much to the north and south, and appears to terminate towards the south on an enormous north-west fold or wide fault." " There is," concludes Mr. Dunstan, " hardly any doubt about this disturbance being a stupendous one."

The question now arises as to whether Pre-Cambrian rocks are confined to the north-western portion of the State. That great areas of country in Queensland, and especially in the northern part, are made up of rocks of apparently ancient type has been long recognised by geologists. In some cases there is good evidence that these are Pre-Silurian in age and in many areas they can be proved to antedate the Devonian period. These formations are treated comprehensively in the official maps of the Geological Survey as " slates, schists, quartzite, etc., of undetermined age." They may represent altered Lower Palæozoic sediments, Pre-Cambrian rocks, or both. It is an almost impossible task in the absence of fossils to determine the absolute ages of the different series, and it is almost as difficult to determine the relative ages of the formations one to another. The latter task must rely upon a study of lithological types, intensity of folding, or degree of metamorphism. Each of these is a dangerous method, as Jack[18] long ago pointed out when discussing this selfsame question. " Lithological resemblance," he said, " is a broken reed, for the same conditions of aqueous arrangement of similar materials, disturbance, pressure, and metamorphism may and do recur in widely separated times." Nevertheless we should remember that these methods have been used very successfully in the elucidation and classification of the Pre-Cambrian complexes of North America, Finland, and elsewhere, and may yet prove of great value in Queensland.

(B) The Etheridge Area.

Jensen[19] is strongly of the opinion that " the Etheridge and Croydon metamorphic gneisses are . . . of the same age as the Cloncurry Series." Dunstan[20] sees " much in common between the granites and old sedimentary rocks in the Cloncurry Series and those of the Etheridge and Croydon goldfields." Ball[21] points out that " Generally speaking, the geological conditions [of the Etheridge field] resemble those on the Cloncurry mineral field," but " On the other hand, metamorphism has not been nearly as intense here as at Cloncurry. . . ." The Etheridge area, to which each of these citations refers, is the nearest development in Queensland of old rocks comparable with the Cloncurry Series. The Etheridge goldfield lies about 200 miles to the N.E. of Cloncurry, the intervening stretch being made up for the most part of Mesozoic sediments. A study of the cores from artesian bores shows that underlying this veneer of younger beds there is a ridge made up of granites and highly metamorphosed sediments. This Jensen[22] calls " the Cloncurry-Etheridge connecting ridge," regarding it as a link connecting two equivalent series. Whether this is so or not, the presence of a ridge of old rocks in this position can hardly be disputed. Such a ridge might well have played a significant and important part in the geography of the past, and may even be regarded as one of the fundamental features in the structure of Queensland.

The main point of difference between the Cloncurry Series and the Etheridge Series (in the restricted sense of Cameron and of Ball) is in the directions of their respective axes of folding, which could hardly be more diverse, the former series striking nearly meridionally and the latter due east and west.

Cameron[23] describes the Etheridge formation as " a series of sharply folded sedimentary strata . . . . They have been bent up into sharp folds over a general east-and-west axis, and consequently are almost invariably found standing vertically with an east-and-west strike, or dipping steeply to the north or south." The same investigator also speaks of overfolding and consequent change in dip from north to south.

(C) Gilbert and Woolgar Areas.

The two features which seem to distinguish the Etheridge Series as thus described from the Cloncurry Series, viz., less intense metamorphism and approximation to E.-W. lines of strike of the former, are also found if one proceeds south from the Etheridge goldfield to the Gilbert[24] and Woolgar[25] fields.

(D) Einasleigh Area.

On the other hand, if one proceeds south-east from the main Etheridge mass one encounters on the Einasleigh and Copperfield Rivers extremely metamorphosed rocks striking almost meridionally.

This interesting series of rocks was described by Dr. E. O. Marks[26] as " contorted gneissose, hornblendic and micaceous schist, having a general strike a few degrees east of north and a dip, as a rule very steep if not perpendicular. The direction of both strike and dip is, however, far from constant." Ball[27] visited the area in 1914 and wrote, " The main body of the schistose rock, it is taken, had a sedimentary origin, but beyond indistinct traces of bedding planes and light cherty banding there is little in proof of the supposition, all original structure having been obliterated during the progress of regional metamorphism . . ." and further, " The original sedimentaries, after tilting, were intruded by basic dykes and subsequently submitted to compressive stresses causing recrystallisation and inducing a well marked north-south schistosity. At a still later date the complex yielded under tensile stresses with the production of an E.-W. fracture system."

The metamorphic rocks of the Einasleigh and Copperfield Rivers appear in the light of the above descriptions so dissimilar from the typical Etheridge rocks as described by Ball that they probably form a distinct and older series, perhaps equivalent to the Cloncurry Series, which they closely resemble in intensity of metamorphism and direction of strike. Jensen[28] boldly states that " North Queensland is largely composed of Etheridgean* [Pre-Cambrian] rocks which form an extension of a massif in Central Australia, the Northern Territory, and Western Australia." But both within the Etheridge goldfield and beyond it Jensen[29] recognises outliers of a younger series, to which he has given the name " Herbertonian"† and which he regards tentatively as of Ordovician age, although he points out that they bear a close resemblance to Pre-Cambrian rocks of the Northern Territory. It is possible that both Jensen's series may be Pre-Cambrian, for Woolnough[30] has expressed the opinion that the metamorphic rocks of the Cloncurry district are not only " undoubtedly of Pre-Cambrian age," but " certainly very low down in the series," and both directions of trend are found elsewhere in Pre-Cambrian rocks of Australia, particularly in Western Australia, where in the north-west province Clarke[31] finds *both* E.-W. trends and N.N.W. trends developed in Pre-Cambrian Series.

(E) The Cape River Area.

The Cape River goldfield is known to possess an enormous thickness of metamorphic rocks, which Daintree[32] divided into three series. The lowest of these, which he described as " interstratified " " laminated

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* It is unfortunate that the " Etheridgean Series" in the wide sense as used by Jensen is distinct from and does not include the Etheridge Series in the narrower sense, as used by Ball and Cameron.

† This is not a synonym for Dunstan's " Herberton Series," which is of Upper Palæozoic age.

granite, and mica- and hornblende-slates," might very well represent a Pre-Cambrian Series. Rands'[33] later report reads, "The schists 'strike' about W.N.W. and E.S.E., and have an average dip of from 30° to 35° to the S.S.W." Cameron,[34] describing the series as seen at Mount Clear View, writes :—"The country rock . . . is a fine-grained mica-quartz gneiss, the beds standing nearly vertically and striking almost west-north-west."

Reid[35] described schists and quartzites from Betts Creek, near Pentland, striking N. 120° E. and dipping very steeply in a direction 30° W. of S., and again, at Oxley Creek,[36] schists of the Cape River Series striking from 132°-160° E. of N. and dipping 42°-47° N.E. In the Cape goldfield we thus appear to have types similar in lithological characters to both the older gneisses of Einasleigh and the younger metamorphic rocks of the Etheridge field proper, while the directions of trend are intermediate between those of these fields.

(F) The Charters Towers Area.

Jack[37 38] has described the metamorphic rocks of this area as quartzites, greywackes, slates, and shales striking N.W.-S.E., covered unconformably by fossiliferous Devonian beds. Pebbles of the Charters Towers Series found in the Devonian beds were already schistose in character. Jack[39] writes, "These once horizontal beds are now thrown into broad folds and probably do not occupy more than one-fourth of the surface over which they were deposited." In Reid's[40] excellent bulletin on the Charters Towers field one finds that Pre-Devonian mica-, andalusite-, and chlorite-schists are very similar lithologically to the Betts Creek schists and their direction of strike and dip is approximately the same. There is very little doubt, writes Reid, "that all these occurrences belong to the one system, and that what was formerly a vast continuous area of probably ancient rocks has been divided into scattered areas by the agents of erosion." With regard to the age of the Charters Towers Series, Reid writes, "In the degree of metamorphism, the apparently great thickness of the beds and the great development of quartzites and schists, it seems more probable [than either Silurian or Ordovician] that they are at youngest of Cambrian age."

With respect to the movements which the series has undergone, the same author writes, "The old rocks are strongly folded and metamorphosed. All traces of bedding planes have been obliterated and a high degree of schistosity developed in what were originally great thicknesses of clay shales. . . . That this was a regional movement of considerable or great extent is evidenced by the similar attitude and metamorphism of the schists at the Cape River goldfield 70 miles to the west. This movement occurred before Devonian time, for the Middle Devonian of the Burdekin River have not suffered noticeable metamorphism and are only moderately folded. The thrust may have occurred as a preliminary movement of the crust prior to the intrusion of the great batholith of granodiorite. . . ." "There is then on this field evidence of only one great tangential thrust, and this occurred prior to the Devonian and probably later than Cambrian time." "The axis of folding lies about 120° east of north, but following it to the north-west it swings more to the west. This may be only a local variation. The schists have very steep dips from 45° to 70° N.E. East of Buckland's Hill the dip is reversed and a small syncline is formed, but west of that the Charters Towers rocks form the eastern limb of an anticline of great dimensions." The stress, Reid thinks, came from the north-east. " A later uplift is necessary to account for the present position of the Burdekin beds" but, writes Reid, " this and all subsequent movements must have been slight compared to the intensity of the Pre-Devonian movements."

With regard to faulting in the Charters Towers area Reid points out that there were three systems of faulting which closely followed each other, and all of which were Pre-Tertiary. These in order of sequence were :—

(1) North-south fairly flat faults, mostly hading east ;

(2) East-west fairly flat faults, mostly hading north ; and

(3) Very small vertical faults oblique to the others.

(G) Clermont Area.

Of this area Jack[41] wrote, " A series of gold- and copper-bearing schists, slates, quartzites, etc., is apparently overlaid unconformably by a bed of limestone of Devonian age." Daintree thought these Lower Silurian or older. The series was made up of " foliated and contorted micaceous and hornblendic schists dipping south-east." The Mount Coolon area may be mentioned here, for Jensen[42] has no doubt that the metamorphic rocks west of the field are part of the Clermont Series (which he regards as probably of Devonian age). North of the field he found " slate, sericite-schist, quartz, and other rocks having the same lithological features as the Pre-Cambrian of the Northern Territory but probably of Devono-Silurian age. The strike of these is N.E., the bedding almost vertical, and the contortion intense."

(H) Gladstone Area.

The author had the opportunity during the past year of examining an interesting series of rocks at Gatcombe Head, the southernmost point of Facing Island, near Gladstone. The series is made up of very highly metamorphosed and crushed schists and gneisses of a very old aspect. They are markedly different from the typical representatives of the Brisbane Schist Series as seen at Gladstone (some seven miles away) both in lithological nature and direction of trend, for whereas the manganiferous schists at Gladstone strike N.N.W. the gneisses and schists of Gatcombe Head strike N. 30° E. The lithological change is so striking that while the normal members of Brisbane Schist Series found further north on Facing Island have been recognised and described as such, the Gatcombe Head rocks are referred to as " Granite" in the Queensland Mineral Index[43] and are mapped as such in the geological map of Queensland issued in 1905. Jensen[44] has investigated the Gatcombe Head outcrops, and writes, " The most metamorphosed series of these old rocks of the Gladstone district is a belt of highly contorted schists and gneisses which probably underlie or are basal to the slates of the turquoise belt." As the turquoise belt is the lowest "zone" of the Brisbane schists as typically developed, and as it is supposed (though not on very conclusive evidence) to be of Ordovician age, the Gatcombe Head series may be and probably is of great antiquity, especially if, as the writer thinks, the marked change in strike indicates the presence of an unconformity between this series and the overlying Brisbane schists. Jensen, while noting the divergence in strike, explains it as "a bend in the trend line," but in his latest publication[45] the same author, after extensive field investigations, has written that strikes "between N.N.E. and N.E. . . . in Central Queensland generally is a very old strike direction" and earlier than both N. and N.N.W. strikes.

(I) The Chillagoe Area.

Ball,[46] in his most interesting publication on this area, points out that both Jack and Skertchley, who had previously examined the area, considered the schists and gneisses met with therein as altered equivalents of the Chillagoe (Silurian) limestone. Ball dissents from this view and writes :—"In my own opinion the abruptness of the change from the relatively unaltered Silurian slates and limestones of Chillagoe and Mungana to the gneisses and schists of Dargalong and Cardross should suffice, in the absence of further evidence to the contrary, for their relegation to an earlier period." Among these ancient metamorphic rocks Ball described "eye gneisses . . . closely allied to the schists and in all probability representing highly metamorphosed sedimentary rocks of great age . . ." and again "hornblende schists grading into granular diorites . . ." At Dargalong the hornblende schist and augen-gneiss strike N.N.W.[47]

(J) Other Areas.

South-Eastern Queensland.

The glaucophane schists and associated rocks of the D'Aguilar Range were thought by Jensen[48] to be very old, and Sir Edgeworth David[49] has suggested that this series, which strikes N.N.W., might be of Archæan age. Wearne[50] has advanced reasons for regarding the Brisbane Schist Series in the type area as possibly Pre-Cambrian, and Saint-Smith[51] has written, "The finely-laminated biscuit-coloured shales of the Wondai district have frequently an exact counterpart at Mount Isa, and as the former are fairly certain to belong to the Brisbane Schist Series, it may well be that all three areas will ultimately be found to be of Pre-Cambrian age." The present writer feels that the absence of any unconformity within the Brisbane Schist Series and the evidence for a Middle Palæozoic age of the upper portion of the series, combined with the fact that the movement causing the schistosity occurred in Devonian or Carboniferous times (see later) renders it highly improbable that any portion of the Brisbane Schist Series is of Pre-Cambrian age. Even if the lowest part of the series is of Ordovician age, the earliest movements to which it has been subjected appear to be considerably later, for no trace of the violent orogenic movement which closed the Ordovician period in New South Wales can be seen, hence the trend lines of the Brisbane Schist Series will be treated in a later portion of this address.

Stokes and Grey Ranges.

Concerning this area Jack,[52] in 1892, wrote, "It may be suspected that the limited areas of metamorphic rocks in the south-western corner of the Colony are a prolongation of the Cambrian rocks of South Australia and the north-western portion of New South Wales." To this Etheridge[53] added the suggestive query, "Is it possible that some of these beds of undetermined age may also represent the Azoic rocks of South Australia, below the Cambrian?" That the assumption that the Grey Range area is closely related to the Broken Hill area has been generally agreed to by geologists, can be seen by the works of David[54] and Andrews,[55] and it is therefore a somewhat remarkable fact, and one that has aroused some comment, that the geological map prepared by Mr. Dunstan to illustrate the Queensland portion of the Great Artesian Basin shows none of these old metamorphic rocks in the south-western portion of the State. But although Mr. Dunstan has expressed his doubt as to the existence of an old series in this part of Queensland, the Queensland Mineral Index contains references to specimens of staurolite and garnet schists collected in this area, and now in the Museum of the Queensland Geological Survey, which are of a distinctly old type, and stand in marked lithological contrast to the Mesozoic rocks from the same area. No strike observations are available, but the general trend of the Grey Range (N.E.-S.W.) agrees closely both in direction and alignment with the strike of the Pre-Cambrian rocks of the Broken Hill area.

Dunk Island.

Professor Richards has informed the writer that on the western side of Dunk Island he noted "mica schist much older in appearance than the Brisbane schist," and very similar to the schists of Gatcombe Head referred to above. The Dunk Island schists are intruded by granites and strike N.N.W. with a steep dip to the E.N.E.

Barnard Island.

The writer has examined specimens of very contorted and metamorphosed gneisses and schists, similar in type to those of Gatcombe Head, from Barnard Island, North Queensland.

Normanby Goldfield.

Jack[56] described slates, quartzites, and greywackes, with mica and hornblende schists, making up most of the Clarke Range. These "have undergone metamorphism followed by extensive denudation prior to the date of the Lower Bowen River formation." Mr. C. C. Morton[57] mentions as the "oldest rock type" in this field "a gneissic granite" in which "extreme metamorphism" has sometimes produced "slabs of biotite schist which grade off into ordinary gneiss." Mr. Morton has kindly supplied the writer with some hitherto unpublished information about this area. The basset edges of the older gneisses of the goldfield strike almost N.E., while the younger schists which are comparable with the Brisbane schists strike almost N.W. This seems to provide a close analogy both as regards the two lithological types present and the respective directions of their divergent strikes with the Gladstone-Gatcombe Head occurrence already noted.

Hamilton and Coen Goldfields.

Ball [58] has pointed out that the prevailing rocks on the Hamilton field are schists and granites, and that it is most probable that the schists represent an ancient sedimentary rock and that they rest on a still more ancient granite floor. The schists are mica-, quartz-, and sillimanite-schists, while "gneiss, perhaps a much altered schist" also occurs. Cameron[59] has observed that this old series of metamorphic rocks strikes N.-S. and has steep dips.

At the Coen goldfield some 20 miles to the north of Hamilton similar schists strike N.-S.[60]

Mount Carbine and Mount Holmes.

Ball[61] describes extremely metamorphosed slates, schists (including ottrelite schist in places), and gneisses with a general N.N.W. trend from Mount Holmes, and very similar metamorphic rocks from Mount Carbine, where "the planes of stratification and schistosity . . . approach the vertical wherever observed . . . their strike varying seldom more than 20 degrees east and west of north."

Summary of Pre-Cambrian and Lower Palæozoic Movements.

Summarising the data considered above, we may say—

(1) That in the Cloncurry district a series of intensely metamorphosed rocks has been folded on lines a little west of north, and that this folding occurred considerably earlier than Lower Cambrian times.

(2) A somewhat similar series, both lithologically and in its degree of metamorphism, was folded on almost parallel lines in the region of the Einasleigh and Copperfield Rivers. In the absence of evidence to the contrary it may be tentatively assumed that the folding movement in this instance was the same as that in the Cloncurry region, and was therefore Pre-Cambrian.

(3) A group of formations, including the Etheridge (in the restricted sense), Gilbert, Woolgar, Cape River, and Charters Towers metamorphic rocks, for the most part considerably less metamorphosed than the Cloncurry and Einasleigh Series, but possibly including representatives of these, was folded on lines which vary from N.W. to W.S.W. but which do not approach the meridional direction. It is impossible on the present evidence to determine the age of the orogenic movement responsible for the present attitudes of this group, but while possibly Pre-Cambrian (but later than the Cloncurry movement) it seems more probable that it occurred at the close of the Ordovician period.

(4) A number of greatly metamorphosed formations occur in North-Eastern Queensland and Cape York Peninsula which have been folded along almost meridional axes.

All that can be said definitely about the age of the folding movement is that it was Pre-Silurian. Its possible relationship to either of the above movements must remain a matter of conjecture until very much more evidence is forthcoming.

(5) The Grey Range, in South-Western Queensland, is made up of metamorphic rocks of an ancient facies. The range trends north-east and may be reasonably considered a prolongation of the metamorphic rocks of the Broken Hill area, in which case it was folded along north-easterly lines in Pre-Cambrian times and has probably not been folded since.

(6) In Central Queensland there occurs a number of old formations of different lithological types which have all been folded on north-easterly axes. In most cases this folding may be reasonably considered as possibly Pre-Ordovician and probably Pre-Silurian, but orogenic movements along north-east axes almost certainly persisted to a considerably later epoch, as will be seen in the sequel.

III. MIDDLE PALÆOZOIC MOVEMENTS.

Some formations, the trends of which have already been dealt with, may really belong to this category. On the other hand, formations which may belong wholly or in part to the Lower Palæozoic (*e.g.*, the Brisbane Schist Series), are dealt with here, for, as will be seen later, the earliest movements affecting them appear to have taken place in Middle Palæozoic times.

The Chillagoe Series.

This is the only undoubted development of Silurian rocks in Queensland, and as such is worthy of special attention. The strike of the series is, according to David,[62] from W.N.W. to E.S.E., while Jensen[63] gives the general trend as between N.W. and W.N.W.

The series thus differs considerably in its direction of strike, and also in its less intense folding and metamorphism, from the Pre-Silurian series a few miles away at Dargalong, which (see *ante*) trends N.N.W. On the other hand the Chillagoe Series appears to conform in its strike directions with the overlying sediments of the Hodgkinson Series, which contain *Lepidodendron australe*[64] and of which Jack[65] writes, "The strata strike on the whole from north-west to south-east . . ." Jensen[66] also regards the Chillagoe and Hodgkinson Series as being folded to the same extent, on the same axes, and at the same time.

The Supposed Silurian of Cairns Range and Toko Range.

Reference has already been made to the discovery of fossils in this district, which lies to the west of Cloncurry. Etheridge referred to the fragmentary fossils as probably of Silurian age.[67] Mr. Dunstan[68] has informed the writer that he has recently collected further fossils which tend to confirm this view, from strata which are practically horizontal and unaltered. If this series is Silurian it stands in strong contrast to the Chillagoe Series which, while little metamorphosed, is strongly folded. This difference is explained by the fact that, as has already been pointed out, there has been no strong folding movement in the Cloncurry district since Lower Cambrian times. The location of folding movements in this instance appears to have moved north and east with the progress of time. Such a change is in accordance with the general principle of a migration of Australian folding movements to the north-east, so often emphasized by Andrews.

The absence of further occurrences of undoubted Silurian rocks is a most serious defect in a study of this kind, but if one infers from the evidence in the Chillagoe area that there was no important earth movement in Queensland between Silurian and Devonian times the defect is not so serious, for representatives of the Devonian period are comparatively widespread. The evidence from New South Wales is not very helpful on this point, for there, according to Andrews,[69] "orogenic movement closing the Silurian sedimentation was irregular in its action."

Brisbane Schist Series (*equivalent to the Amamoor Series and the Gladstone Series*).

A consideration of this series may be helpful in reaching a decision on the question of Silurian folding movements. The series is made up of a very great thickness of strata, which are strongly folded and somewhat metamorphosed. As regards their age, they have at various times been referred to almost every period from Pre-Cambrian to Permo-Carboniferous.[70] At present they are officially designated "Ordovician," but the writer feels safe in saying that the consensus of opinion among Queensland geologists at the present day is that the Brisbane schists represent more than one period. This was long ago maintained by Jensen,[71] and is supported both by the great known thickness of the series and by its natural partition into broad subdivisions on which have been bestowed the somewhat infelicitous term "Zones" by the Chief Government Geologist. Mr. Dunstan has recognised three such subdivisions, the lowest of which, the "Turquoise Zone," is closely comparable with rocks of Ordovician age in New South Wales. The uppermost or "Serpentine Zone" is very similar to the Great Serpentine Belt of New South Wales and other serpentines of Eastern Australia, and may reasonably be regarded as of Devonian or Carboniferous age.[72] From immediately below this, Richards and Bryan[73] have described radiolarian jaspers remarkably like those of the Woolomin Series (Lower Devonian) of New South Wales.

The Brisbane Schist Series thus seems to include both Silurian and Post-Silurian strata which appear to be strictly conformable. This would indicate the improbability of any great folding movements in South-Eastern Queensland at the close of the Silurian period. As Richards[74] has pointed out, the folding, which produced the N.N.W. strike, high dips, and schistosity of the series, occurred after the intrusion of the Serpentine, for weathered outcrops of the Serpentine show well-developed schistosity along N.N.W. lines. On the other hand the presence of fragments of schist, as such, in the Enoggera granite, as shown by the writer,[75] indicates that the movement producing the schistosity antedated the intrusion of the granite, which event is supposed to have taken place at the close of the Palæozoic Era.

The Brisbane Schist Series and its equivalents form the basement of the geological structure of South-Eastern Queensland and extend with few interruptions in a N.N.W. direction from Coolangatta (on the borders of New South Wales) to the vicinity of Rockhampton. Although there are local variations, the strike is remarkably constant about N.N.W. The most important exception to this statement is in the Kilkivan-Black Snake district, where, according to Jack (see later), the schists strike N.E. The author has, however, received from Mr. C. H. Massey the information that near Kilkivan the schists have the normal N. 20° W. strike and the Kilkivan Serpentine belt strikes N. 10° W.

The Burnett Area.

This area is remarkable for the fact that in it numerous observers have found evidence of a persistent N.E. strike which, while it does not altogether replace the N.N.W. strike, seems quite independent of it. That the N.E. strike is not merely a local deviation of the N.N.W. is shown by the fact that both have been strongly developed quite close to each other. The most southerly representative of the N.E. group previously recorded seems to be between the Kilkivan and Black Snake areas, where Jack[76] notes that "The country . . . is entirely of schists . . . which have a steep inclination to the north-west," but the writer has noticed further south, in the Cressbrook Creek-Biarra area, an older metamorphosed series striking N.E. and dipping very steeply to the S.E., and a younger less-metamorphosed series striking N.N.W. and dipping steeply to the W.S.W. Both these steeply dipping series are overlain by gently dipping Mesozoic sandstones. In the Paradise goldfield, Jack[77] notes that "All the way down Yarrabil Creek, from Gebangle to near its junction with the Burnett, slates and sandstones dip steeply to the N.W." Rands[78] describes, from Mount Biggenden, siliceous slates which dip very steeply N.W., but Ball,[79] working in the same area, noted that the strike of the slates "near the granite is generally N.N.W.," the dip being everywhere great and generally to the W.S.W. Ball[80] also noted, in the Perry Scrub district, clay schists with a N.-S. strike, high dips and extensive folding, while a half-mile to the east were comparatively unaltered slates striking N.E., with a steep dip to the S.E. The same observer[81] has reported from Degilbo highly altered sedimentary strata striking both N.N.W. and N.E. and nearly vertical, while in the Mount Perry district[82] "The intruded sedimentaries along the eastern side of the [granite] *massif* are markedly schistose, they are steeply tilted, and they usually trend in a north-south direction." Of the same district Reid[83] writes, "A series of metamorphics —schist and dense quartzites . . . extend . . . a distance of 16 miles. . . . The series throughout have almost a north and south strike and are tilted on end . . . they are almost certainly the oldest rocks of the district." Jensen[84] writes that while the rocks of the Biggenden-Booyal-Mount Shamrock belt trend approximately N.-S., "The strike of the series met with west of Gayndah, as at Phillpot Creek, is between N.N.E. and N.E."

In the light of this evidence there seems no simple relationship between the two sets of strikes, but it appears that the great granitic intrusions are associated with the more northerly trend which is in accordance with David's[85] well-known generalisation. Jensen, as has been noted, is firmly of the opinion that the north-easterly is a very old strike direction for Central Queensland, "pointing in general to Siluro-Devonian age,"[86] while north strikes he regards as Upper Palæozoic. If the N.E. is the older strike direction in this district it may be related to the north-easterly strikes in the Clermont, Peak Downs, and Mount Coolon districts, which were considered tentatively as of Lower Palæozoic age.

The Silverwood Area.

The N.N.W. trend is well represented in the Devonian rocks of Southern Queensland, where Professor Richards and the writer[87] have examined the Silverwood-Lucky Valley area in some detail. Of this district they write, "The area has been subjected to several movements of different types and different degrees of intensity, and these have been in large part responsible for the complexity which is now so evident in the field. These movements, though so different in nature and in the structural phenomena which they have produced, have one factor in common. They all give expression to the one dominating and persistent trend. The axes of folding, the lines of faulting, the strike of the older rocks—every indication of what has been so aptly termed the "grain" of the country—show a N.N.W.-S.S.E. direction, and this in its turn is reflected by the major physiographical features of the Silverwood-Lucky Valley area." The earliest of these movements was one of severe compression about N.N.W. axes, and its age is thought to be "Post-Devonian and Pre-Permo-Carboniferous." Though it is admitted that the Permo-Carboniferous representatives in the area may have been less strongly folded on the same lines, the authors express the opinion that the main folding took place at the close of the Devonian and was synchronous with the "Kanimbla Epoch" of Sussmilch.[88]

Jensen[89 90] has noticed that in the Jibbenbar-Sundown district (near Stanthorpe) joint planes striking N.E. have been regarded in the past as the strike of the beds. Jensen supposes that these joint planes are the result of pressure metamorphism, and advances reasons for regarding the true strike as being between N.N.W. and N.W. and the dip north-easterly.

The Gladstone and Rockhampton Areas.

The nearest occurrences (in Queensland) of undoubted Devonian beds to those of Silverwood occur in the Boyne River district to the south-west of Gladstone. These have been described by Ball.[91] From this point fossiliferous limestones of Devonian age occur at intervals along a N.N.W. belt to the Duke Group of the Northumberland Isles. The strike of these outcrops varies from N. to N.W. and the dip is usually steep, so that the series treated broadly seems to be in general conformity with the Gladstone portion of the Brisbane Schist Series, though folding may not be so close or metamorphism so intense.

In this area further examples of a north-easterly strike, in marked discordance with the prevailing N.N.W. strike, have been noted. Jensen[92] described, from Many Peaks, cherts and slates striking N.E. and dipping S.E. at 45°. The noticeable change in strike between the Brisbane schists at Gladstone and the older metamorphic rocks at Gatcombe Head has already been mentioned, and in the Raglan-Ulam area a further sharp division is seen. Jack[93] speaks of the country rocks of the Raglan gold-fields as being nearly vertical and striking N.-S., and Jensen[94] mentions schists and slates near Raglan striking N.-S. with a westerly dip, but Saint-Smith[95] describes, from a point seven miles south-west of Raglan, Devonian limestones with *Favosites* striking N.E. and practically vertical. Again, Jack[96] states that North Keppel Island is composed of slates and grey-wackes dipping at high angles to the north-west.

The Burdekin Series.

Jack[97] when delivering his presidential address to Section C of the A.A.A.S. pointed out that the fossiliferous strata which form this series " are not greatly disturbed at the Burdekin, Fanning and Reid ; but on the Broken River they have a dip of about 60°. In the first-named places they rest directly but unconformably on quartzites, slates, greywackes and shales, and sometimes on granite." In all but the last-mentioned place the dip seems to be in the neighbourhood of 20° and the strike variable, but according to David[98] the folding is generally along N.E. axes. The series as a whole seems never to have been subjected to very severe orogenic movements. Reid[99] has expressed the opinion that " The Middle Devonian limestones of the Burdekin River . . . have not suffered noticeable metamorphism and are only moderately folded ; and further that " All subsequent movements must have been slight compared to the intensity of the Pre-Devonian movements." The steep dips noted by Jack at the Broken River seem to be found also on the track from this river to the Gilbert goldfield, where Jack[100] mentions Devonian rocks striking N.E. and dipping on the whole at high angles to the N.W.

In the Kangaroo Hills region both Gibb Maitland[101] and Saint-Smith[102 103] have doubtfully referred a series of somewhat crushed and metamorphosed quartzites and slates which dip almost vertically and strike approximately N.E. to the Devonian period, and Jensen[104] maps them as such. It is difficult to reconcile such steeply dipping strata from the Broken River and Kangaroo Hills areas with the moderately folded limestones of the type district.

The Hodgkinson and Palmer Areas.

Tenison-Woods[105] in 1880, in describing the strata of the Hodgkinson goldfield, stated that the strike of the slates was north-east and south-west, but later workers, while admitting that in places the strike is very variable, conclude that the general trend of the beds is more nearly north-west. Jack,[106] for instance, writes: "The strata strike, on the whole, from north-west to south-east . . . their dip is usually towards the north-east, and at a high angle, approaching the vertical." Of the same area he writes ". . . it may be presumed that pressure of the sort which results in the production of cleavage has been very feebly exerted in this region."

The strata of the Palmer goldfield, which Jack[107] regarded as of the same age as the Hodgkinson, have a general strike from N.-S. to N.N.W.-S.S.E. and are nearly vertical, but "have not suffered any appreciable degree of metamorphism." Jensen[108] has lately redefined the Hodgkinson Series comprehensively as a "belt . . . from Mareeba, through the Hodgkinson goldfield, the Mitchell River antimony mines, and the Limestone (Groganville) goldfield to Maytown." He adds: "The general dip of this Hodgkinson Series is to the north-east . . ." and "The series is usually found dipping steeply but folded in a regular manner. Intense plication is, as in the Chillagoe Series, typically absent."

With regard to the age of these extensive series, the only direct fossil evidence is the occurrence at Thornborough of *Lepidodendron australe*,[109] which in Northern Queensland might indicate either a Devonian or a Carboniferous age. In Jack's[110] opinion "It is possible that the Hodgkinson and Palmer beds may represent part of the missing strata between the Dotswood [Devonian] and Star [Carboniferous] beds."

Jensen[111] considers the Hodgkinson Series to be of Devonian age and to occupy a syncline between the Chillagoe beds and the sea.

Dunstan[112] includes most of the Hodgkinson and Palmer areas in his Herberton Series (not to be confused with Jensen's "Herbertonian"), which series he regards as of Carboniferous age, as a result of the record by Stirling[113] of *Rhacopteris* from Newellton in the Irvinebank area. While Dunstan regards the series containing *Rhacopteris* to be the same as that containing *Lepidodendron australe*, it seems quite possible that they may represent two quite distinct series, for Stirling found *Rhacopteris* in beds that were but slightly disturbed, which overlay a very much more disturbed metalliferous series which he regarded as of Siluro-Devonian age and which may possibly represent the metalliferous Hodgkinson Series in which *Lepidodendron australe* was found. A definite decision on this point is essential before we can decide whether the Hodgkinson Series was folded before or after the Carboniferous Period.

Pascoe River Area (Cape York Peninsula).

This area is of particular importance in a study of this kind on account of its geographical position. The meagre nature of the geological information which had hitherto been available from this quarter has lately been strongly augmented by Morton's account of the area published last year.[114] Here a series of auriferous schists which on lithological grounds Morton regards " as old, if not older than the Brisbane schists" strike between N.N.E. and N.E., are steeply dipping, and occasionally show acute folding. Morton quoted Jack as describing, from a neighbouring area, gneiss and slate, the latter striking N.E. At Two-mile Creek a fossiliferous series overlies the auriferous schists. The strikes and dips of this series " showed marked variations" but were in the main between N.N.E. and N.E. This series had been folded but showed a preponderance of dips to the N.W. The only fossils which Morton was fortunate enough to obtain from this series were identified by Dr. A. B. Walkom as " Lepidodendroid stems—*Cordaites*, and seeds which probably belong to same." This authority was of the opinion that a Carboniferous age was indicated, although the evidence as set forth seems to admit also the possibility of a Devonian age. The most striking and surprising feature about the area is the prevailing N.N.E. to N.E. strike of both the folded Palæozoic Series. The presence of schistosity in the earlier series and its absence from the later show that at least two important earth movements, one Pre-Carboniferous and one Post-Carboniferous, are represented.

Summary of Middle Palæozoic Movements.

Summarising the data concerning the movements of Middle Palæozoic formations in Queensland and considering the areal distribution of the trends as set out on the accompanying map (Fig. 1), we find :—

1. That from the New South Wales border on the south almost to Cape York on the north there are representatives of two distinct and divergent trends.
2. The N.E. trend appears to be the older one, and may have resulted from the same movement which produced the north-east strikes of Clermont, Peak Downs, and Mount Coolon (which were included with some hesitation as of Lower Palæozoic age), and of Gatcombe Head and Normanby.
3. The N.N.W. trend which seems everywhere to be later than the Devonian Period and may be in part Post-Carboniferous.
4. Thus, though they were preceded and followed by orogenic movements of great intensity, the Middle Palæozoic periods themselves seem to be free from major earth movements as far as Queensland is concerned.

IV. UPPER PALÆOZOIC MOVEMENTS.

(A) Carboniferous.

The Herberton Series.

It was pointed out in the previous chapter that Jack regarded the Hodgkinson Series containing *Lepidodendron australe* as possibly being intermediate in age between the Burdekin beds (Devonian) and the Star Series (Carboniferous); that Jensen was definitely of the opinion that the Hodgkinson Series was of Devonian age; that Dunstan included the *Lepidodendron* beds with the *Rhacopteris*-bearing beds of Newellton in the one series which he called the Herberton Series, and which he considered (with some doubt) to be equivalent to the Star Series. The possibility that the little altered *Rhacopteris* beds may represent a younger series than the steeply dipping metalliferous *Lepidodendron* beds has also been considered.

At Mount Mulligan Ball[115] describes and illustrates "fossiliferous Permo-Carboniferous coal measures" separated by "a sharp unconformity" and with "an equally sharp palæontological break" from Carboniferous beds containing *Lepidodendron*. The section illustrating these observations strongly suggests that in this area at least the last important folding movement was after the deposition of the *Lepidodendron* beds and before the deposition of the Permo-Carboniferous.

The fossiliferous beds of the Pascoe River area which have also been dealt with can be reasonably assigned for the present to Dunstan's Herberton Series.

The Star Series.

This is the best-known series of strata of Carboniferous age to be met with in the State. Jack[116] describes their attitude in the type area as follows:—"Disposed with only a gentle dip, and consisting of unaltered stratified rocks, it contrasts in a striking manner with the surrounding granites, gneisses, slates, and schists." A little further south in the valley of Keelbottom Creek, the series is a little more disturbed but the strike is variable and the greatest angle of dip recorded by Jack is 40°. Still further south near the Sellheim mineral field the series "appears to form a basin, the synclinal axis of which is a short distance south of Mount McConnell Station." At Mount Wyatt near the head of the Sellheim River Jack cites Daintree as having found "slightly inclined grits and sandstones of the Upper Devonian *Lepidodendron* beds, resting on the upturned edges of a series of blue and grey slates and shales." Again Gibb Maitland is quoted by Jack as referring "with hesitation" to the Star Series, beds from the Upper Burdekin that are "almost horizontal," and are arranged in the form of s synclinal trough the longer axis trending north-west," and which rest unconformably upon the upturned edges of an older series striking N.E.

In speaking of the Carboniferous beds as a whole Jack[117] says: "The Star beds have undergone, so far as I have observed, no very great degree of metamorphism. Portions of them, such as the Drummond beds, may be said to have undergone no metamorphism at all."

The Drummond Series.

Jack[118] describes in some detail an interesting east-west section along the Central Railway where it crosses the Drummond Range. For twenty miles the section to the west of Bogantungan shows a somewhat variable strike with a maximum dip of 12°, but for the eight miles immediately west of Bogantungan the dip is consistently to the east at 2°. Bogantungan itself is on the axis of a synclinal trough, and as far eastward as Withersfield the dip is towards the west. It is difficult to reconcile this section with Jensen's[119] statement, that the Star beds in this portion of Queensland are considerably folded, and that an unconformity separates them from the overlying "Lower Bowen" Series. In another publication[120] the same author makes the observation that "the Star beds in Central Queensland are much more folded and much more irregularly folded than the Lower Bowen which rests on them. Yet they cannot be called intensely folded."

The Rockhampton Series.

This series is typically developed in the neighbourhood of Rockhampton and Stanwell, where Carboniferous fossils are found, but there is no reason to suppose that the series is limited to the type locality. It seems rather to form a belt running in a north-north-westerly direction and reaching from west of St. Lawrence perhaps with interruptions at least as far south as Eidsvold, from which locality the writer has examined well-preserved specimens of the genus *Lithostrotion* in the possession of the Queensland Museum, while Morton[121] has collected *Lepidodendron* from the same area.

It is difficult to generalise with regard to the attitude of the Rockhampton Series, for while in the type district they dip at angles up to 70°, Mr. Morton informs the writer that what evidence there is suggests that in the neighbourhood of Eidsvold the same series is horizontal or nearly so. (It is possible that the steep dips at Rockhampton were produced by a very much later movement, for that city lies on the prolongation of the most important of the late Mesozoic anticlines. See Fig. 2.)

In the central coastal district Ball[122] has described acid volcanic rocks of supposed Carboniferous or Permo-Carboniferous age, and states: "Similar eruptions had previously been met by me in Broad Sound and out to the north-east . . . The possibility of the great trend lines or stratigraphic grain here swinging round to the north-east from the usual north-north-west is advanced as worthy of investigation."

The most southerly beds of Carboniferous age are those described by Ball[123] from the Texas area, from which he has collected specimens of *Lithostrotion.* Of the attitude of these he writes: "The strata . . . between Gore and Graysholm [are] everywhere steeply tilted and with prevalent east-west strike, which is nearly at right angles to the dominant trend of Eastern Australia. Near Bracker Creek the strike is deflected abruptly to the south-west, and hence it is that the same rocks are to be met with in the vicinity of Texas, beyond which township they swing round sympathetically with the great bend in the Severn River below Bonshaw." The significance of this marked change in trend will be considered in a later portion of the address.

(B) PERMO-CARBONIFEROUS.

The Bowen Area.

It is fortunate, for the purpose of this address, that Mr. Reid [124] has just published the results of his examination of the Bowen coalfield. Referring to earth movements in the area he writes : "The main structure of the coalfield is a very asymmetrical syncline, converging at the northern end, and widening towards the south. The dips on the extreme eastern side are very steep, angles ranging from 40° to the vertical, averaging probably 50° to 55°, while the easterly dips on the west side average about 5° to 7°. The structure appears to be not at all complicated, except at the northern end, where severe compression of the beds has introduced overthrust faulting, minor synclines and anticlines and elbow bends in the strike lines." The complications in this corner of the field were a local result of "the great compressive movement which operated from the oceanic side and formed the great Bowen River syncline." The direction of the axis of the syncline is shown by the geological sketch map, which accompanies the report, to be N.N.W. (true). A feature of the area is the remarkably straight outcrop made by the steeply dipping eastern limb of the Marine Series which strikes N. 30° W.

Reid [125] regards the barren Redcliffe Series which overlie the Bowen Series as being from analogy with the Mount Mulligan area, probably of Triassic age. He disagrees with Jack who thought an unconformity separated these sandstones from the Bowen measures. This is an important point, for it places the age of the movement which produced the Bowen syncline at least Post-Triassic.

The Bowen River coalfield, as Reid [126] points out, "lies at the northern apex of a vast Permo-Carboniferous area (which extends unbroken to almost as far as Taroom on the Upper Dawson, a distance of 400 miles to the south-south-east . . ." In this southern extension "the Permo-Carboniferous rocks . . . still dip rather steeply, in a general westerly direction, along the inland side of the Coastal Range but the basin has widened up to 150 miles." As a result of his examination of the Delusion Creek (Upper Dawson) area, Reid concludes that "The sequence in the southern extremity of the Permo-Carboniferous basin appears therefore almost identical with that of the Bowen River. Further the rocks are found to strike and dip uniformly in both areas and both have steep dips on the eastern margin, flattening to very low angles followed west." In the light of these generalisations the writer feels that only short references need be made to the more important areas of Permo-Carboniferous rocks lying within this great basin.

Dawson-Mackenzie Area.

Dunstan [127] [128] has examined this area in some detail, as the result of which he has concluded that there is within the series an important unconformity which separates the "undulating" and "contorted" Lower Bowen from the almost horizontal Upper Bowen. Reid[129] doubts the existence of this unconformity, and suggests that it results from comparing the lower rocks from the eastern steeply dipping side of the basin with upper strata considerably west of the disturbed zone. In other words that the differences in intensity of folding are due to areal distribution rather than to difference in age.

In the same report Dunstan refers to "the regularity of stratification" and "the absence of disturbances" and "the large extent of coal country comprised in the Mackenzie River and Central Railway area."

Clermont Area.

Ball[130] reports that in this neighbourhood "The Permo-Carboniferous strata occupy a series of depressions [in the underlying schists] and are the remnants of a once continuous, gently undulating formation." This attitude is also well illustrated by Dunstan.[131]

Morton[132] refers to fossiliferous freshwater Permo-Carboniferous beds, which "appear to be very flat or only gently undulating" from Nogoa Downs in the Emerald district.

Carnarvon-Springsure Area.

Jensen[133] in describing the Permo-Carboniferous strata from this area points to the facts that they are only gently folded, that they are separated by an unconformity from the underlying Carboniferous, but that they are succeeded by a conformable sequence which extends without a break to Walloon (Lower Jurassic) strata.

Rockhampton-Proserpine Coastal Areas.

A number of separate occurrences of Permo-Carboniferous age which have long been known in this area have lately been re-examined by Reid,[134] who concludes that "The major structure of the area is a large asymmetrical syncline the axis of which is roughly parallel to the coast line" [*i.e.* N.N.W.]. In the Tooloombah-Styx area he notes that "The . . . beds are undulating . . . but the general dip . . . is approximately north-east at a gentle angle," and further that "there is little, if any, angular unconformity between the Permo-Carboniferous and the Cretaceous Styx coal measures at this point." At Oakey Creek the strike is very regularly N.N.W., the "gentle and regular dip to the E.N.E. indicating freedom from disturbance."

Isolated Areas West of Bowen.

Jack[135] notes fossiliferous Permo-Carboniferous strata dipping from 20° to 30° to the S.W. near the Sellheim mineral field. "This series appears to be faulted on the east against granite and on the west against the Star beds."

Marks[136] describes carbonaceous *Glossopteris*-bearing strata horizontally disposed near Pentland; and Reid[137] from Betts Creek, in the same district, notes gently dipping Permo-Carboniferous strata, which have "a strong stratigraphical discordance" with underlying schists, while they are overlain by "Desert Sandstone" with a slight unconformity. Reid[138] suggests with regard to this occurrence that "The eastern boundary of the Permo-Carboniferous beds . . . may form a strong convexity to the west, which sweeps round the schist and granite of Gilberton and the Etheridge and turns to the east again in the vicinity of the Mount Mulligan Tableland."

The Oxley Creek Permo-Carboniferous beds in the same area are interesting on account of their exceptional attitude, for while Reid[139] shows that they unconformably overlie the old Cape River Series, the younger beds themselves exhibit "eve y variation in attitude between the vertical and horizontal," but dip consistently to the south. "Close to the contact with the schists the Permo-Carboniferous beds are exposed standing on end for some distance, but they become flatter towards the south and for some distance are quite horizontal." Mr. Reid informs the writer that he regards the steep dips here as merely local and in no way indicating regional folding of the Permo-Carboniferous strata. These beds are unconformably overlain by practically horizontal (?) Jurassic sandstones.

Marks[140] has reported, from the Galah Gorge in the Hughenden district, *Glossopteris* and *Vertebraria* in coal-bearing beds lying practically horizontal.

Two occurrences which may possibly be of Permo-Carboniferous age are described by Ball from North-Western Queensland. The first of these, at Mount Quamby[141] in the Cloncurry district is a conglomerate series moderately folded and striking N.E. and down-faulted into the vertical Cloncurry Series along N.-S. faults. The second occurrence is near Lawn Hills where Ball[142] describes and figures "a great anticline" of which the "Zinc Hills are really the core" made up of faulted grits and sandstones which show no signs of crushing and metamorphism but rather gentle uplift.

These beds have been referred to the Silurian by Daintree and Jack, and to the Devonian by Cameron, but Ball thinks they may be Permo-Carboniferous.

Occurrences in the Cape York Peninsula.

Little River Coalfield.

This field according to Jack[143] has "been wedged, by two faults, into the midst of an older series of greywackes, slates, quartzites, etc. After having been subjected to such a degree of lateral compression that its strata were inclined at high angles, it was covered by a cake of Desert Sandstone." This view, that the steep dips are the result of trough faulting and not of folding, has received the support of all geologists who have since visited the field. David[144] has emphasized the tectonic importance of this infaulted block, and has suggested that there is a causal relationship between it and the break in the coast-line at Princess Charlotte Bay.

Mount Mulligan Coalfield.

Ball [145] describes and figures the Mount Mulligan Coal measures as separated by " a sharp unconformity " and " an equally sharp palæontological break " from underlying Carboniferous beds containing *Lepidodendron,* and overlain by gently dipping Triassic shales containing fossils typical of the Ipswich Series. In an earlier publication Ball [146] wrote that the Mount Mulligan coal measures " have subsided between trough faults, of which the displacement must have been very great indeed, probably to be measured in thousands of feet." He adds : " Otherwise than for the trough-faulting, the measures as a whole do not appear to have suffered dislocation to any great extent."

With regard to both the Little River and Mount Mulligan areas Ball[147] makes a very interesting suggestion : " The agreement in trend," he writes, " of the Little River and Mount Mulligan areas, is at least peculiar and with a very slight effort we can imagine a great rift valley to have extended in the distant past (possibly in Mesozoic times) down the Peninsula from the latitude of Cooktown to beyond that of Cairns." As we have seen, David would prolong such a trough through Princess Charlotte Bay.

South-Eastern Queensland.

Gympie Goldfield.

Rands[148] described the attitude of the Gympie Series (in the restricted sense) as follows :—" The strata dip with great regularity at an average angle of from 20 to 22 degrees. On the northern portion of the field the direction of the dip is, as a rule, a little to the north of east ; on the southern portion it is to the east-south-east." In describing the metamorphic effects found on the field Jack[149] wrote of the strata : " They are only slightly disturbed. Sedimentary rocks which have undergone no alteration alternate with others which have become indurated and semicrystalline." Jack attributes this selective metamorphism to " the intrusion of masses of diorite" while Jensen[150] asserts that the altered strata are " merely metasomatised by circulating waters in the upper zone." In the same publication Jensen writes : " The true Gympie rocks at Gympie occupy an area about seven miles long, and perhaps five miles wide, around which appear phyllites with an older facies." " The Gympie rocks are all characterised by intense secondary silification, but the remarkable schistosity which the rocks outside the mining area show is not seen within the mining district. This fact is a strong indication that the true Gympie rocks are newer than the others. . . ." " Most of the country mapped as Gympie " is " far more metamorphosed than the true Gympie." In a later publication[151] the same author saw " weighty reasons for regarding the Gympie area as a small subsidence area." Such a conclusion is certainly supported by the geological map of the area prepared by Dunstan[152] and others, which shows that the Middle (True) Gympie Series is separated from the more schistose Upper Gympie and Lower Gympie for the most part by faulted boundaries. Within the mining area are numerous strike faults (slides) and dip faults (cross-courses). The former are approximately in a N.N.W. direction, while the latter are somewhat radially arranged from N.E. in the northern portion of the field to E.S.E. in the southern portion.

An alternative explanation of the attitude of the Gympie beds has been tentatively put forward by Ball,[153] who, when describing strata from Gold Top (near Kilkivan), writes: "Lithologically, the rocks resemble those of the Middle Gympie Series" and "we may be here on the western leg of a huge anticline, of which Gympie marks the eastern."

The Silverwood Area.

Richards and Bryan[154] have described fossiliferous beds of Permo-Carboniferous age from this area. These consist of four isolated blocks which constitute what the authors have termed "the Fault Block Series." As the result of a combination of strike (N.N.W.) faulting and dip faulting in the underlying highly folded Silverwood series of Devonian age, blocks of the overlying sediments have been dropped down into the older series and are thus preserved as relics of a once continuous covering of Permo-Carboniferous rocks. "This," the authors point out, "accounts for the finding of Permo-Carboniferous fossils in the heart of country made up of the steeply dipping and highly folded 'slates,' 'schists,' and 'metamorphics' of the older writers."

With regard to the time at which this faulting took place Richards and Bryan write: "The age of the faulting, both strike and dip, is definitely Post-Permo-Carboniferous, and as the Walloon Series is not affected it is presumably Pre-Jurassic. Further, as the edge of the granite shows no sign of disturbance the faulting took place before its intrusion, but if the authors are correct in their estimation of the age of the granite the time interval between the faulting and the intrusion must have been a very short one. The intrusion of the granite thus followed closely and was probably related to the faulting."

Silverspur Area.

Ball[155 156] has described a very interesting occurrence of fossiliferous Permo-Carboniferous strata from Silverspur. Here ". . . crinoids, producti, and spirifers may be observed in the schistose pebbly mudstone of Conglomerate Hill . . . and on the northern slopes of Jack White's Hill, where the shells are much distorted." "All of the strata have been locally and variably metamorphosed." "The variability in the intensity and trend of the schistosity, jointing and bedding . . . is extreme." ". . . the stratigraphy is very much more complicated than previously acknowledged, the evidence in general being contrary to the assumed uniform strike of the Permo-Carboniferous strata." Ball suggests that the area has suffered heavy block faulting into four distinct blocks with quite diverse strikes.

Relationship of Permo-Carboniferous to Carboniferous.

In Queensland (as in New South Wales) there has been much doubt and considerable difference of opinion as to the relationship of the Permo-Carboniferous formations with the underlying Carboniferous.

Of the Star Series, Dunstan[157] writes: "Its relation to the Lower Marine [Permo-Carboniferous] Series and to the Devonian has not been established," and of the Drummond Series "Its relation to the associated older and younger rocks is not understood." Since the latter statement was written Jensen, as we have previously noted, has referred to a "clearly apparent" unconformity between the Drummond Series and the overlying Permo-Carboniferous strata. The Rockhampton Series, Dunstan states, is "apparently conformable with the Lower Marine Series of the Dawson and MacKenzie Rivers." It is difficult to reconcile this with the evidence from the Stanwell area, where, according to Jack,[158] the Permo-Carboniferous coal measures of Dinner Creek are "unaltered, and not much disturbed sandstones and shales . . . clearly distinct from the highly inclined and considerably altered fossiliferous rocks [of the Rockhampton Series] of Stony Creek, Stanwell."

Again, in the Styx River Area, according to Jack[159] "Mr. Smith found his 'Central Queensland shales' (Rockhampton beds) unconformably overlaid by the strata of the Styx River coalfield [Cretaceous]." But in the same area Reid, as we have seen, has noted "that there is little if any angular unconformity" between the Permo-Carboniferous and the Styx Series, thus indirectly pointing to an unconformity between the Carboniferous and the Permo-Carboniferous in this region.

At Mount Mulligan we have noted that the Permo-Carboniferous coal measures rest unconformably on highly tilted *Lepidodendron*-bearing strata, which are provisionally regarded as the equivalents of the Star Series (but which certainly may be older). Lastly, at Gympie the Permo-Carboniferous (Middle Gympie) are, according to Dunstan, "probably unconformable" with the more schistose Lower Gympie, which are doubtfully referred by Dunstan to the Carboniferous period but which may again be older.

In the light of such contradictory evidence it would be unwise to attempt a definite decision. Some of the Carboniferous Series seem to have been affected by the great orogeny which closed the Devonian period while others were unaffected, but the data are insufficient to show whether there is any definite areal relationship between the unfolded and folded beds.

Summary of Upper Palæozoic Movements.

1. Of the various formations of known or supposed Carboniferous age only the *Lepidodendron* beds of the Hodgkinson, Palmer, and Pascoe areas (all of which occur in the Cape York Peninsula) can be described as highly folded.

2. These probably represent a somewhat lower horizon than the gently dipping *Rhacopteris* beds of Newellton in the same area.

3. Of the undoubted Carboniferous formations neither the Star Series nor the Drummond Series is highly folded, but the Rockhampton Series further to the east has been strongly folded near Rockhampton. However, it is possible that this was the result of a much later movement.

4. A folding movement of the first importance which was initiated towards the close of the Devonian period was prolonged in some portions of the State well into the Carboniferous period.

5. The Permo-Carboniferous formations can be divided into three groups :—

A. The Great Bowen-Mackenzie-Dawson basin,—a wide shallow syncline with a steep eastern limb.

B. Various isolated areas in which horizontal or gently dipping strata of Permo-Carboniferous age rest unconformably on much older series.

C. Down-faulted blocks of Permo-Carboniferous age in which steep dips and crush effects have in some cases been found but in none of which has actual folding been demonstrated.

6. No folding movement of any importance separates the Permo-Carboniferous strata from the conformably and disconformably overlying Mesozoics.

V. LOWER MESOZOIC MOVEMENTS.

The Ipswich Series.

This series is made up of the oldest Mesozoic strata so far discovered in Queensland with the possible exception of the formation described by Jensen[160] from the Carnarvon Range area, which lies immediately above and is apparently conformable with freshwater beds of Permo-Carboniferous age, in the same manner in which near Sydney the Narrabeen Stage overlies the Permo-Carboniferous Series. The Ipswich Series as described by Walkom in 1918 [161] had a very restricted distribution, but that the series is considerably more extensive than was then thought is shown by the correlation with the Ipswich Series of—

(1) The Esk Series by Reid and Morton[162], and by Walkom[163] ;

(2) The lower Mesozoic strata of the Carnarvon area by Jensen[164] ; and

(3) The lowest portion of the Tiaro Series (typically developed in the Brooweena-Aramara area) by Bryan and Massey.[165]

The age of the Ipswich Series as determined by Walkom[166] from palæontological evidence is either Upper Triassic or Rhaetic, so that a quite considerable time-gap separates the series from the uppermost members of the Permo-Carboniferous. (In New South Wales this gap is partly filled by the Narrabeen and Hawkesbury Stages.) Reid and Morton described from South-Eastern Queensland what they took to be a Mesozoic Series, older than the Ipswich Series, under the name " Borallon Series."

The most marked feature of this series was the steeply inclined attitude of its strata. Reid and Morton interpreted this as an indication that the series had been highly folded and denuded before the deposition of the Ipswich Series unconformably upon it. Cameron[167] and Marks[168] opposed the view that the steeply dipping strata formed an independent series, and supported the earlier hypothesis of the former[169] that they represented highly tilted members of the Ipswich Series along a line of folding and dislocation which could be traced for many miles both south and north of Ipswich. Following the controversy which ensued and as the result of further investigations in the field, Reid and Morton abandoned their hypothesis of a Pre-Ipswich Mesozoic Series and now accept Cameron's explanation.

The Bundamba Series.

The Ipswich Series is overlain by the Bundamba Series with apparent conformity, but the rather marked change in lithological type, and the absence of fossils in the upper series, may indicate a time-break. This is evidently the opinion of Reid[170] who states that the two series are separated by a disconformity. The Bundamba Series has a somewhat more extensive development than the Ipswich Series but is limited to Southern Queensland.

The Walloon Series.

The Walloon Series, which conformably succeeded the Bundamba Series, has a very wide distribution in Queensland. Not only is there a very extensive outcrop of this series to the west of the Main Divide, but extensions of this yet further to the west, beneath later formations, have been proved by the records of numerous bores, and in addition numerous small isolated areas belonging to the series are found scattered over a great portion of Eastern Queensland. Most Queensland geologists will agree with Walkom[171] that "these occurrences represent the remnants of a deposition which probably covered the greater part of Queensland." The probable movements in Queensland during Lower Mesozoic times have been summarised by Walkom[172] as follows :—" In Queensland, the dominant movement from the beginning of the Ipswich epoch was a subsidence. This movement was not continuous ; there were, at least, breaks represented by the base of the Bundamba Series and of the Walloon Series, and there may have been further breaks within the series. At the time of these breaks there was probably a cessation of sedimentation, accompanied by a slight uplift before the downward movement reasserted itself ; the predominance of the downward movement is proved by the ever-increasing area covered by the Lower Mesozoic sediments."

Although very marked changes in palæogeography, in fossil content, and in lithological character separate the uppermost members of the Walloon Series from the base of the Cretaceous Maryborough (Marine) Series, the latter appears to be invariably conformable with the former, which does not appear to have suffered any folding movements before Cretaceous times.

VI. UPPER MESOZOIC MOVEMENTS.

The Cretaceous deposits, while providing a marked contrast in lithological type and contained fossils with the Walloon Series which they succeeded, yet resemble them closely in two features, viz., their distribution and their attitude. Like the Walloon Series, the overlying Cretaceous sediments occur as a very extensive development west of the Main Divide and as a restricted development east of the Divide, which is almost certainly the relic of a much more widespread deposit.

Rolling Downs Series.

This is the name given to the huge areal development of marine sediments found west of the Main Divide, and forming the impervious cover of the Great Artesian Basin. The change from the extensive lake areas of Walloon times to the widespread shallow sea in which the Rolling Downs Series was deposited proves a continuance of that quiet and general subsidence which, we have seen, was the characteristic movement of Lower Mesozoic times. Again the movement was probably not continuous, for there is probably a disconformity of considerable time-value separating the Walloon and Rolling Downs Series; and Mr. F. W. Whitehouse,[173] who has given especial attention to this question, has pointed out that there is also " a large gap in the succession between the lower beds of the Rolling Downs (Aptian) and the succeeding (U. Albian) horizon."

For the most part the Rolling Downs Series is almost horizontal, such dips as there are being the result of what David[174] has described as " a great sagging . . . of the region between Lake Eyre and Roma, as well as on a meridional direction from midway between these points and the Gulf of Carpentaria." Jensen[175] speaks of the series as being " gently folded after the same manner as the Walloon," and of the latter he writes,[176] ". . . the entire region is folded into gentle anticlines and synclines on approximately north-south axes," and that " there are a series of monoclines and flattenings, or terraces passing from south to north which have developed on east-west axes." The same author[177] writes of the Tambo-Barcaldine area: " The analysis of bore data points strongly to the conclusion, that there are folds in the Cretaceous Marine, and that the area on which oil prospecting was carried on is the eastern flank of a considerable fold." It is this gentle folding which has enabled Jensen[178] to detect the presence of an unconformity between the Rolling Downs Series and the overlying horizontal Winton Series. In his own words, " It is at the top of the Marine [Cretaceous] Series we get the first marked unconformity since the inception of the Lower Bowen." In another publication Jensen[179] speaks of this unconformity as " clearly apparent," but before his work the Winton Series had been regarded as quite conformable with the Rolling Downs Series (see Dunstan[180]). This is an important point, for if Jensen is right it sets the age of the last slight folding movement (at least for Central Queensland) within narrow limits.

Winton Series.

The Winton Series is a horizontal freshwater series with small unproductive coal seams, which is regarded by Dunstan as Cretaceo-Tertiary in age on account of the large percentage of dicotyledonous leaves found among fossil plants of a somewhat older facies.

Maryborough Series.

This is a marine series extending from Baffle Creek on the north to the neighbourhood of Maryborough on the south. Though the series is thus fairly extensive it only forms the western portion of what was once a much more extensive Cretaceous area. The Maryborough Series has usually been regarded as the equivalent of the Rolling Downs Series although Walkom[181] has pointed out that the two may not be contemporaneous, for his study of the plant fossils of the conformably overlying Burrum beds has convinced him that they are of Lower Cretaceous age, and that the Maryborough beds may thus be of Jurassic age. Whitehouse's statement (quoted above) to the effect that the lowest horizon of the Rolling Downs Series is the equivalent of the Aptian of Europe would thus certainly indicate that not only the Maryborough Series but even the Burrum Series is considerably older than the Rolling Downs Series.

The Maryborough Series is very much more highly folded than the Rolling Downs Series, and this has always been explained in terms of the areal distribution of the folding movement. While this is probably correct it should be borne in mind that the different intensities of folding in these two series may reflect a difference of age.

No more need be said of the movements which have affected the gently dipping Mesozoic sediments, lacustrine and marine, west of the Main Divide, but the movements of the Mesozoic strata in the south-eastern corner of the State require a more complete statement.

Concerning these the geologists of Queensland seem unanimous on two points, viz., that the Ipswich, Bundamba, Walloon (= Tiaro), Maryborough, and Burrum Series have all been affected by folding movements, and that they were all folded at the same time. Some would go further and include the Permo-Carboniferous strata as having first been folded with the Mesozoic sediments. Thus Reid[182] states that " In the Styx district Permo-Carboniferous and Cretaceous beds appear to be conformable and to be both affected by the same folding" ; and Jensen[183] has in the Carnarvon district failed to find any indication of an unconformity between the Permo-Carboniferous and overlying Ipswich Series, which have been folded together. Reid[184] on the other hand has advanced the radical view that the folding movement affecting all these also involved Tertiary sediments. One can hardly do better than quote Walkom[185] on the folding of the Mesozoics in this part of the State. He writes : " In South-Eastern Queensland, a study of the distribution and directions of dip shows that the Lower Mesozoic rocks have been considerably folded, and that the folding in some cases gives place to faulting. The folding takes the form of a series of anticlines and synclines, whose axes are in a direction approximately N. 30° W.-S. 30° E."

This generalisation of Walkom still holds but can now be applied to a much greater area than that to which Walkom referred, for field work has shown the existence of greater and more persistent anticlines with a N.N.W. trend, and the writer is of the opinion that the apparent complexity of the structural geology of Queensland from Bowen to the New South Wales border can for the most part be simply and satisfactorily explained in terms of a series of lines about which severe folding has taken place separated by areas of gently dipping strata. (See Fig. 2.)

In some places these lines are the axes of anticlines, in some places of monoclines, and in other sections they are important fault directions. Their most general characteristic is a short steeply dipping western limb and a long gently dipping eastern limb.

These parallel anticlines are probably the more important corrugations in a geanticline of very great dimensions—the partial restoration of which is shown in Fig. 3.

The first and most westerly of these important structural lines has been described by Jensen[186] as " a very pronounced anticline " extending " southwards through Springsure " and passing on " with greatly diminished intensity " to the railway line between Blythesdale and Wallumbilla.

Jensen[187] has drawn attention to a second " major geanticline " of Post-Walloon age which " extends from the Dalveen district . . . under the eastern flank of the Darling Downs through Camboon and Rannes." If this suggested anticline be plotted on a map (see Fig. 2) two striking features are revealed. The first of these is the exact parallelism of this with the Springsure line. The second feature is that at its northern end Jensen's line is continuous with, and differs very little in direction from, what the writer takes to be another very important structural feature—viz., the line made by the steeply dipping sediments which form the eastern edge of the great Dawson-Mackenzie-Bowen Basin.

The third and best known of these anticlines probably formed the apex of the great geanticline. At its southern end between Beaudesert and Boonah this line has been described independently and in some detail by Reid[188] and by Morton.[189] The former refers to it as ". . . a simple, large, asymmetrical anticline, the axis of which, . . . for about 18 miles, trends N.N.W. to S.S.E. The steep dips are on the easterly side, while the western flank dips very regularly and gently." Reid also summarises the evidence in favour of faulting on approximately N.-S. lines with downthrow to the east along the eastern flank of the anticline, and concludes that " This faulting is believed to be connected with the rather acute folding on the east flank of the anticline."

This anticline has been traced in a northerly direction past Mount Flinders towards Ipswich. At Churchill occurs an interesting section to which Cameron[190] has drawn attention. Here the anticline is so asymmetrical as to almost warrant the term "monocline," but here it is the *western limb* which has the steep dips, the eastern being almost flat. A little further north at Ipswich, the Bundamba Series and with it the underlying Ipswich Series are, according to Cameron, sharply bent over a north-north-westerly striking axis of folding. This fold is accompanied by a heavy fault with downthrow to the west. To the north of Ipswich this great fault (accompanied in the writer's opinion by numerous smaller parallel faults) is still to be seen, and is coincident with the junction of the old Brisbane Schist Series (on the east) and the Lower Mesozoics of the Brisbane Valley (on the west). Cameron[191] stated that it can be traced as far as Northbrook, but it is probable that this important tectonic line extends much further to the north, parallel to the Brisbane River. Reid and Morton[192] believe it to reach to near Goomeri on the Nanango Railway, at which place Reid [193] has recently described and figured it as "The Moondooner Anticline." Reid [194] has also stated ". . . a regular N.N.W. line passes from Gayndah through Ipswich to Beaudesert. Faulting and intense folding mark this line and west of it the Mesozoics are scarcely disturbed." It may even be that the remarkably straight line running N. 30° W. which forms the boundary between the "Devonian" (on the east) and the "Gympie," which is almost certainly Carboniferous in this area (on the west), and which runs parallel to and some 12 miles to the east of the Burnett and Nogoa Rivers, may be a further continuation of this important structural feature,[195] and an extension of the line yet further to the north to Rockhampton and beyond still follows, approximately, important geological boundaries, and would in the writer's opinion afford as likely an explanation of the presence of Broad Sound and the trend of the coast in that neighbourhood as that put forward by David.[196] The author has also received quite independent evidence in support of the existence of the northern extension of this anticline, from Rev. C. H. Massey, who writes regarding the distribution of the Lower Mesozoic rocks: "There must have been a huge anticline, the crest of which was somewhat east of Gayndah."

A fourth anticline of great structural importance extends from the neighbourhood of Maryborough to Baffle Creek. This is in the nature of a series of anticlines and synclines as developed at Maryborough, where it has been studied in detail by Richards[197] and Dunstan,[198] but that the structure as a whole can be viewed as a great anticline with a steeply dipping western limb is the view of the writer, based on a considerable amount of field investigation in this area.

To illustrate the trend of these great denuded anticlines Fig. 2 has been prepared, while Fig. 3 is an idealised cross-section which shows the relationship of the different anticlines to the great East Queensland Geanticline.

With regard to the forces which produced these anticlines, David[199] writes of the Maryborough example that " on the whole the steeper slopes face inland, the folding pressure came from the east. . . ." Of all the other anticlines Jensen[200] is of the opinion that " these anticlines were the result of a thrust from the east, from the Pacific," while Reid regards the Collinsville section as having also been produced by thrusts from the east.

Such consensus of opinion indicates that we may assume with reasonable safety that the pressure which brought about the orogeny of late Mesozoic times was from the Pacific in a direction W.S.W. This view supports the conclusions of David, Hedley, Jensen, Walkom, and others, but militates against Andrew's well-known hypothesis.

This brings us to a consideration of the intensity of the folding of the Mesozoic strata in South-Eastern Queensland. Both Jensen[201] and Richards[202] have been criticised by Walkom[203] for stating respectively that " our Mesozoic sediments show no folding of consequence" and " folding movements of only a very gentle nature have taken place since the Palæozoic era." In the writer's opinion, both these statements would be more accurate if modified by the addition of the words " except along a few well-defined lines" (the more important of which are the four dealt with above). But we should remember that the intensity of folding is not necessarily an indication of the fundamental importance of a movement.

The date at which this folding took place is admitted by all to be after the deposition of the Burrum beds (Lower Cretaceous of Walkom), but how long after is a matter of dispute. That it occurred long before the great Tertiary basaltic outpourings is shown by a section examined by the writer at Bromley's coffee plantation near Pialba, where horizontal basalt rests upon the levelled and truncated edges of the highly folded Maryborough Marine Series. According to Walkom,[204] " This same folding took place before the Cainozoic, since it has not affected any of the Cainozoic rocks of South-Eastern Queensland." The same writer quotes Cameron as his authority for stating that folding of Tertiary sediments in South-Eastern Queensland is restricted and appears to be about approximately meridional lines. Reid[205] in a paper submitted to the last meeting of the A.A.A.S. takes a very different view. He states : " There is definite evidence of strong folding movements along the Queensland coast between latitudes 22° and 28° some of which extend into the Tertiary period. Cretaceous and Tertiary rocks are involved and apparently some of the earlier Tertiary volcanics." The evidence tendered in support of this statement will be considered under " Cainozoic Movements."

Summary of Mesozoic Movements.

Throughout the whole of the Mesozoic era, with the exception of the very latest portion of it, there was a slow and gradual though discontinuous movement of subsidence over the whole area now represented by the Great Artesian Basin. This was followed by a slight folding movement of very gentle type. At the close of the Cretaceous period a movement of uplift was initiated, with the result that the freshwater Winton Series was deposited with a slight unconformity upon the marine Rolling Downs Series.

East of the Main Divide a similar slow and discontinuous subsidence is indicated, but here the change to equally gentle uplift occurred somewhat earlier, and resulted in the deposition of the freshwater Burrum beds conformably over the marine Maryborough Series.

At the close of the Cretaceous period (or possibly early in the Cainozoic era) the Mesozoic Series in Eastern Queensland suffered a widespread movement which resulted in folding about axes running in a direction N. 30° W. Of these axes four appear to be of paramount importance. Of the existence and direction of these axes there can be no reasonable doubt, but their lateral extension is a matter of conjecture. They appear to be strictly parallel and are spaced with almost mathematical precision. Each anticline appears to have a short, steep western limb, and a long, gentle eastern limb, so that a complete section involving the four has a somewhat step-like appearance. A general section (Fig. 3) has been compiled by the writer, extending from the neighbourhood of Injune to Fraser Island, which illustrates in a simple manner the nature of the movement.

That the movement probably resulted from a thrust from the E.N.E. is indicated by the steep dips to the west, the presence of minor folds, and the presence of overthrust faults at Collinsville. An alternative explanation, that the structure may have resulted from non-uniform epeirogenic movement, is suggested by the facts that the highly folded areas are arranged in narrow zones along straight lines, that they are commonly accompanied by faults of a normal type, and that exceptionally, as near Beaudesert, the steep limb of the anticline faces east.

VII. CAINOZOIC MOVEMENTS.

Tertiary and Quaternary deposits are much more widespread in Queensland than is generally recognised. The fact that little importance is usually assigned to them results primarily from the fact that they have received so little attention from geologists. No systematic attempt at correlating the different occurrences has yet been made, but it is most highly improbable that the numerous deposits listed by Dunstan[206] as of Tertiary age represent one and the same horizon.

(A) Folding Movements.

A study of the literature dealing with the several Tertiary series developed in Queensland shows that, while for the most part they are gently inclined, they exceptionally show quite steep dips, and in some places are actually folded.

Ipswich District.

Walkom[207] quotes Cameron as his authority for a "comparatively restricted" movement of Tertiary strata producing folds in "an approximately meridional direction." At Redbank Plains in the same area the writer has noted fossiliferous Tertiary sediments striking N. 10° W. and dipping steeply (up to 60°) to the W. 10° S., but whether this is the result of faulting (which the writer suspects) has not been determined.

Strathpine.

Mr. Morton[208] has recently discovered fossil leaves of a Tertiary aspect, one and a-half miles west of Strathpine Railway Station, in beds which strike N.N.W. and dip steeply to the E.N.E. These steep dips Morton holds to be the result of faulting.

Gladstone District.

In describing the Tertiary Series at Lowmead, Ball[209] writes: "The strata have been much disturbed since their deposition, and in many places they dip as much as 30°, though never for long distances, the structural forms prevailing being short anticlines and synclines." "The crops in the southern part . . . have a north and south trend, but in the central part their strike is east and west, and at the northern end they have swung round again towards the north-west."

In describing the Tertiary sediments from the Narrows, in the same publication, Ball states that ". . . it is known that the strata have been thrown into slight undulations, and exceptionally the dip amounts to as much as 45 deg."

Reid[210] states that the *folded* Tertiary strata are confined to that part of Queensland between the 22nd and 28th parallels of latitude, and to the east of a line joining Beaudesert, Ipswich, and Gayndah (which we have seen is an important structural line of the folded Mesozoic strata). Reid uses this fact of distribution as one of his arguments against Andrews'[211] hypothesis of Tertiary unity in Eastern Australia, but it seems to the writer that such distribution is more readily explained on Andrews' own principle of a north-easterly march of the locus of folding movements with the passage of time.

Reid, in the same publication, makes the statements that "This folding continued from the close of the Cretaceous at least well into the Miocene," and "There is definite evidence of strong folding movements . . . some of which extend into the Tertiary period. Cretaceous and Tertiary rocks are involved and apparently some of the earlier Tertiary volcanics." One point in this statement needs investigation—that is, the assumption that the movement responsible for the folds in the Tertiary strata was the same as that which folded the Mesozoic sediments into those great anticlinals which we considered in the last section. With regard to this point, Cameron[212] describes the Tertiary beds in the Ipswich area as ". . . a considerable thickness of post Trias-Jura rocks, lying with a pronounced unconformity on the [Ipswich] coal measures." At Redbank Plains, Dunstan[213] describes the Tertiary strata as "a thin superficial deposit resting on the irregular surfaces of the Ipswich Coal Measures and Bundamba Sandstone. . . ." Fig. 3 in the same publication shows gently dipping Tertiary strata resting on the eroded surface of the Mesozoic Series.

With regard to the direction of their respective axes of folding, there seems to be a considerable divergence between the Mesozoic strata and the Tertiary Series, for in the Ipswich district the latter, we have seen, strike almost meridionally and the former strike N. 30° W. Neither in the Lowmead nor in the Narrows occurrences do the Tertiaries show the well-defined trend which Reid's hypothesis would lead us to expect.

For the Ipswich district at least, the writer is of the opinion, as the result of considerable field work in the area, that the Tertiary strata lie unconformably on several different horizons of Mesozoic strata, and that they have not therefore participated in the principal folding movements which have affected the Mesozoic Series in that area.

Reid uses, as one of his principal arguments, Morton's descriptiou of the attitude of one exposure of the Tertiary basalts in South-Eastern Queensland. Of this Morton[214] writes: "Immediately to the north-west of Widgee Mountain, . . . is an inlier of sedimentaries . . . which have been folded. On the road . . . a section can be seen showing basalts of different types . . . apparently tilted, in conformity with the immediately underlying [Mesozoic] sedimentaries, at angles from 45 deg. to 60 deg. in a westerly direction. The overlying volcanics of the middle division [of Richards] in the hills close by show no sign of this movement, and are therefore assumed to have post-dated it."

It is certainly difficult to reconcile this section with the general conclusions arrived at by Richards[215] as the result of an extensive study of the volcanics of this area. There is nothing, either in the text or in the accompanying sections of that author, to suggest either that the Lower Basalts have been tilted or that they were not strictly conformable with the overlying volcanic rocks. On the other hand, Fig. II. Plate XI. shows the horizontally disposed Lower Basalts at two places (Mount Meerschaum and Tambourine Plateau) resting upon the upturned and truncated edges of Mesozoic strata. The writer saw much of this area in company with Professor Richards, and two of the facts which most impressed him were the horizontality of the volcanic rocks and the folded (though not strongly folded) nature of the underlying Mesozoic strata. The base of the Lower Basalt is such a clearly defined and readily recognisable horizon that one cannot but think that, had it been subjected to the folding of the underlying Mesozoic strata, the fact would be obvious in the field, and many more occurrences like that described by Morton would have been found.

Again, the line of junction between the top of the Lower (Basaltic) Volcanics and the bottom of the Middle (Rhyolitic) Volcanics is another well-marked and easily discernible line, and any unconformity between the two should have been speedily detected, but, although many such junctions have been studied, no sign of unconformity has been found.

Morton has himself pointed out one difficulty in accepting the age of the folding movement as after the Lower Volcanics and before the Middle Volcanics, for, assuming that the steeply dipping strata near Mount Widgee were affected by the same movement that caused the development of the main (Beaudesert) anticline, one must "provide the time necessary for the denudation of at least 6,000 and probably nearer 8,000 feet of strata from the crest of the anticline," before the extrusion of the Middle Volcanics.

In the light of all the evidence the writer feels that it would be unwise to accept Reid's hypothesis, which involves a major earth movement followed by prolonged denudation between the times represented by the Lower and Middle Volcanic Series. One is forced to the conclusion that the steep dips of the Mount Widgee basalt are the result of a movement either of folding or faulting later than the important orogeny which folded the Mesozoic strata.

(B) Faulting Movements.

The faulting movements which have been recorded for the Cainozoic era in Queensland can, so far as their time of origin is concerned, be divided into two natural groups, viz.—

(1) An older group, the members of which either have no effect at all upon the physiographical features of the present day, or have only produced such effects indirectly, through, for instance, the operation of differential weathering;

(2) A younger group, the members of which are usually recognised by the fault scarps and other marked physiographic features of which they have been the direct cause.

(1) Older Faults.

It is difficult to decide the exact age of faults in the first group, mainly on account of the sporadic development of Tertiary deposits in Queensland, and the absence of any reliable scheme of correlation of these deposits. In many cases all that can be decided is that the faults affect late Mesozoic deposits but are only indirectly reflected in present-day physiography. Many of them may thus be associated with the considerable movement which, as we have seen, appears to close the Mesozoic era. But there certainly remain others, which have affected Tertiary strata but no longer present fault scarps or other physiographic evidence of their existence, such as that mapped by Cameron at Ebbw Vale, and those presumably responsible for the steep dips of the Tertiary strata at Redbank Plains, and the highly tilted series near Strathpine in which Morton[216] has recently found Tertiary fossils. Other small faults can be seen in the Tertiary sediments at Rocklea and other localities near Brisbane. These latter are interesting since in some cases they also affect the overlying basalts, but they are of small throw and of very minor importance.

East Moreton Fault System.

Under this caption, Ball[217 218] has described a series of faults, whose linear arrangement is reflected in some of the major physiographical features of South-Eastern Queensland. An eastern set consists of two fault lines, the southern one a line connecting Hemmant (near Brisbane) to D'Aguilar (on the Kilcoy Railway), while the northern fault Ball supposes to extend from a point on Obi Obi Creek (twenty miles to the south of Cooran), along the eastern scarp of the Woondum Tableland and thence to the eastern edge of the Neerdie granite. Ball speaks of "the possible identity" of this fault with the southern one, but one should note that, if the two are continuous, they have somewhat divergent trends. Of the first of these faults, which strikes N.W., Ball writes: "The chief interest of this great fault lies in its separating strata of Mesozoic age [on the north-east] from a Palæozoic complex [on the south-west]."

The western set of faults follows a line from the neighbourhood of Mount Flinders, through Ipswich to Northbrook, and possibly extends up the Brisbane River Valley and along the Kimbombi escarpment. Such a line, as we have already seen, separates different geological series along a considerable portion of its length.

The geological evidence in support of most of this western line of faulting is very strong, while the geological evidence for faulting at both extremities of the Hemmant-D'Aguilar line is also strong, and the writer, under the guidance of Mr. Morton who has lately been investigating that area, has seen much evidence of faulting and crumpling of the Brisbane Schists midway between these points and on the supposed line of faulting.

While having little doubt as to the existence of these faults and their great geological significance, the author hesitates to follow Ball in his interpretation of their effect on the physiography of the region. For Ball concludes, "these two faults define a horst that formerly extended from the south-east corner of the State right across the Moreton district and probably entered Wide Bay. This can be advanced as something more than a working hypothesis. . . ." This may be so, but Mr. Ball appears to consider that the D'Aguilar, Woondum, and Kimbombi escarpments are now true fault escarpments, as yet but slightly eroded and consequently very new (for such topographic forms have usually a very short existence), and uses them as such in his evidence.

The writer, although, as he has stated, he agrees with the geological evidence for the existence of the faults, is not prepared to admit that these escarpments are the *direct* result of the faulting or that the faulting was as recent as Ball supposes, for the following reasons :—

1. Those parts of the fault lines seen at Hemmant on the eastern line, and at Ipswich on the western line, may reasonably be regarded as dating from the widespread movement which closed the Mesozoic era, for they are each associated with folded Mesozoic strata.

2. The fault line at D'Aguilar cuts *across* the line of the escarpment.

3. Ball himself points out that "The Blackall Range is on the downthrow side of the fault; and its Mesozoics owe their preservation to the basaltic lavas that flooded the lower lands after their subsidence." Thus the faulting at this point antedated the extrusion of the basalts and therefore took place long before the present cycle of erosion.

4. The Palæozoic strata are so deeply dissected by erosion, that all such transient features as fault scarps must long ago have disappeared.

5. The present arrangement of the major physiographic features of the area can be readily explained in terms of differential erosion, for, as

it happened, soft rocks were thrown down on each side of a hard resistant block. (Had the reverse been the case the Horst of Tertiary times might to-day present the appearance of a Trough.)

One possibility that should be noted here is that of repeated (posthumous) faults along the same plane of weakness, spread over a long period, resulting in an intermittent rejuvenation of such physiographic forms as fault escarpments, the latest of which might survive in the topography of the present day.

The writer has noted several other observations of faults which antedated the present cycle of erosion. Most of these have affected late Mesozoic rocks (as for instance the Maryborough Marine Series in the Pialba area) but have not affected overlying Tertiary basalts. Their exact age is in most cases indeterminate, but they appear to have followed closely the important folding movement which occurred late in the Mesozoic era.

(2) Younger Faults.

Of the second group of Cainozoic faulting movements, those which can be detected by their direct and still-evident results on the physiography, much more has been written. The age of such movements is fixed within reasonably narrow limits, for they have followed the last great outpourings of the Upper Volcanics and are therefore most probably no older than Pleistocene. Such a conclusion is supported by the newness in the appearance of the fault scarps.

Andrews[219] in 1910 drew up a "List of some important Fault Scarps and Senkungsfelder in Eastern Australia." Among those which he seems to have considered definitely proved are five examples from Queensland. From north to south these are as they appear in Andrews' table :—

Name of Fault System.	Locality.	Uplift, Senkungsfeld, or Downthrow.	Amount of Vertical Displacement.	Remarks.
(2) Bellenden Ker ..	North Queensland	Uplifted block	Very large	An element of the Great North Queensland coastal scarp. A mountain 5,000 feet high here presents a precipitous scarp to the coastal plain.
(6) North Queensland scarp	Lucinda Point to north of Cooktown (250 miles)	Uplift ..	Very large	This may be partly due to flexing.
(13) Mount Eliot	Near Townsville ..	Uplift ..	Large ..	Mr. W. G. Poole has recently described faulting action in this region (Aust. Ass. Adv. Sci. 1909).
(10) Darling Downs faults	South-Eastern Queensland	All ..	Some very large	Under examination by Mr. R. A. Wearne, of Ipswich.
(20) Macpherson Range ..	Boundary of New South Wales and Queensland	Uplift ..	Very large	Not examined in detail. Cross-faulting.

Marks,[220] referring to these five fault systems, states "Not one of these alleged Queensland faults has a basis of unquestionable evidence, for none of them has been confirmed by detailed examination of the ground or observed in any section, and in none of them has the possibility of differential weathering been excluded. Grave doubt or actual disproof has been put on some and different interpretations put on others."

While agreeing whole-heartedly with Dr. Marks on the general advisability of geological evidence in confirmation of physiographic evidence of faulting, the writer is of the opinion that the physiographic evidence can be quite as definite and equally as reliable on this point as geological evidence. It is notorious that one of the gravest and commonest failings of the geologist is his tendency to assume faults on doubtful geological evidence. In the neighbourhood of Cunningham's Gap in South-Eastern Queensland (No. 10 in Andrews' list), faulting has been urged by Wearne and Woolnough[221] and has received the definite support of Richards,[222] Jensen,[223] and others who have visited the locality. Here Reid has pointed out that the geological structure is not simply explained in terms of faulting, and he has abandoned the fault hypothesis in favour of differential weathering. In the opinion of the writer, who has several times visited the area, the physiographic evidence of faulting is so strong as to justify the assumption of faulting on that alone, and the fact that the geological structure, as we know it, is not simply explained by faulting, means merely that a more detailed study of the geology is necessary.

The faults tabulated in Andrews' list are all supposed incidents in "the great uplift which closed the Tertiary" and "isolated the coast from the interior." The amount of this uplift must have been very considerable, and Ball[224] has calculated that in North Queensland the "Cook uplift" was in the neighbourhood of 1,000 feet. As Andrews puts it (p. 469), ". . . the continental edges were upwarped until incoherence was established. At this stage relief of the marginal strain on the continent was obtained by faulting and flexing in areas parallel to the oceanic depths." Such an hypothesis affords a ready means of satisfactorily explaining all the observed physiographical features, and has met with general acceptance by Australian geologists. It is not, as far as the writer is aware, opposed by any geological evidence.

Quite a number of recent faults in addition to those in Andrews' list have been determined on physiographic grounds. Thus Ball has mentioned several, the most important of which seems to be one to the west of St. Lawrence. Here he states, "That the eastern face of Connors Range is a fault scarp can scarcely be doubted."[225] If this is so, a very important fault running parallel to and a few miles west of the present coast-line is indicated.

A noticeable fact is that, in Queensland, the physiographic evidence for faulting is strongest where the continental shelf most closely approaches the coast-line, but the Connors Range fault of Ball appears a most important exception to this generalisation.

Reference should be made here to the recent work of Richards and Hedley,[226] who have explained the present outline of the coast of North Queensland in terms of the hypothesis of W. Hobbs,[227] who supposes that many of the coastal and other physiographic features of the continents reflect "fracture patterns" either on N.-S. and E.-W. lines or on N.E.-S.W. and N.W.-S.E. lines. Text-figure 6 of Richards and Hedley's work indicates how the alternating headlands and bays between Princess Charlotte Bay and Cape York seem to follow a simple fracture pattern along the cardinal directions. Such a pattern might well be a reflection of meridional lines of tension set up as a result of the important north-south faulting which we have been considering, and of less important transverse fractures.

It is a remarkable and probably significant fact, that at Cape York the fracture pattern suddenly changes to N.E.-S.W. and N.W.-S.E. In the words of Richards and Hedley, ". . . the general form and disposition of the islands about and to the west of Cape York, in Torres Strait, suggest that they have resulted from a fracturing of a mass of porphyry along lines at right angles to one another and following directions bisecting the angles between the cardinal points." This change in the fracture pattern takes place at a critical point for, as the authors cited point out, "Where two large land masses such as Australia and New Guinea are hinged together is just the point where movement would be expected to cause fracture," and the new directions taken by the fracture lines at this point may reflect, as Richards[228] suggested in an earlier paper, the influence of the New Guinea trends.

Another interesting point in this connection is that at Princess Charlotte Bay the meridional line of the fracture pattern coincides in position with one of the supposed great faults in late Palæozoic times which let down the Little River and Mount Mulligan coalfields into the surrounding older rocks. (Compare Text-figure 6 of Richards and Hedley with Fig. 2 of the present address.)

Recent Movements.

As pointed out by Marks, there is probably no point about which the geologists of Australia are more unanimous than that there has been in recent times, and within the present cycle of erosion, a general subsidence of the coast-line of Eastern Australia. The evidence of drowned valleys, coastal islands, and submarine topography is so clear, so consistent, and so indisputable, that the writer sees no necessity to present it in detail.

With regard to the vertical extent of this movement Andrews[229] seems to consider that it has not been uniform, and writes: "A study of the coast from Sydney to Cooktown, however, reveals variations from north to south in the extent of drowning. . . ."

Ball,[230] working in the Tewantin area, concluded from the recent nature of plant specimens obtained in bores in the consolidated coastal sands, that "A minimum subsidence of 200 ft. is necessitated by the contained plant remains, and if the deposition of all the consolidated sands took place at about sea-level a minimum subsidence of 400 ft. would be involved with subsequent re-elevation of at least 200 ft."

That the age of this movement of subsidence was recent is self-evident, but Andrews[231] has stated that he sees evidence of "variations from north to south . . . in the time involved since such movement, all, however, taking place in very recent geological times."

David,[232] following Penck,[233] has tentatively suggested that this subsidence was not caused by any movement of the land but that during the preceding ice-age the sea-level was lowered by the same amount. "This lowering of sea-level," writes David,[234] "was due to the locking up of enormous volumes of sea-water which went to form some eleven millions of square miles of Pleistocene ice-sheets." Consequent on the melting of the ice-cap to its former dimensions, the sea is supposed to have returned to its former level and to thus have "drowned" the Australian coasts to the extent of 200 feet. This hypothesis has been ardently supported by Daly.[235]

Following this recent submergence, there has been in still more recent times a slight uplift, ample evidence of which is seen along the Queensland coast, in the shape of raised beaches, low coastal plains, inland sea-cliffs, wave-cut platforms now in process of destruction, and river terraces. Of the detailed accounts which have been published concerning this elevation, mention may be made of Dunstan's work in the Keppel Bay area; of that of Marshall, Richards, and Walkom[236] who have described raised beaches, caves in the cliffs now above sea-level, and elevating fringing coral reef now dead from Holbourne Island; of Richards and Hedley[237] at Stanley Island, and Jensen[238] in the Moreton area. Everywhere the amount of elevation seems to have been of the same order of magnitude, and this has caused David[239] to suggest that "The so-called raised beach of about 15 feet is so general around Australia, that it is probably due to a recent eustatic negative movement of the sea." Daly[240] goes even further and thinks he sees evidence of a world-wide movement of this nature. This hypothesis is supported by David,[241] who writes: "[an] epoch of greater warmth than at present (about 4 deg. Fah.) . . . followed on soon after the final melting away of the last of the great pleistocene ice-sheets. This raised the sea-level apparently all over the world by about 15 feet. Subsequently, possibly through the resorption of sea-water by very recently expanding polar ice-caps, sea-level has since been lowered by 15 feet." Daly's hypothesis has been disputed by W. B. Wright[242] and others in England, while Hedley[243] is in disagreement with its application to Eastern Australia and has advanced evidence of more than one movement of the coast in an upward direction.

Andrews,[244] referring to this recent emergence, has stated that the movement of elevation was "vibratory," and that the effects of elevation are more marked in the northern than in the southern area of the East Australian coast.

Summary of Cainozoic Movements.

1. The folding movement along N. 30° W. axes which closed the Mesozoic era may have been continued into very early Tertiary times in the eastern portion of the State.

2. Strata of Tertiary age have been somewhat folded in that part of Queensland to the north-east of the Beaudesert-Gayndah-Rockhampton line.

3. This latter folding was considerably later than, and along more nearly meridional lines than, that which ushered in the Tertiary era. It was the last folding movement in Queensland and preceded the great Tertiary volcanic outpourings.

4. Faulting mainly along N.N.W. to N.W. lines appears to have taken place in South-Eastern Queensland in early Tertiary times. These faults preceded the Tertiary Volcanic Series and are therefore only indirectly reflected in the present arrangement of physiographic features.

5. A later system of faulting has been described mainly on physiographic evidence. This appears to have been confined to the coastal region, and to be more marked in those portions where the edge of the continental shelf closely approaches, and is parallel to, the present coast-line.

This faulting post-dated the Volcanic Series and its effects are seen *directly* reflected in the coastal topography. Hence it must have been very recent.

6. A general subsidence of the coastal region has occurred within the present cycle of denudation. The amount of this subsidence was probably in the neighbourhood of 200 feet.

7. A still more recent movement of elevation, though of a much smaller amount, has in part compensated for the earlier marked subsidence.

VIII. THE SEQUENCE OF EARTH MOVEMENTS IN QUEENSLAND.

Consideration of the data collected and commented upon in the preceding chapters, and plotted on the accompanying maps, has led the writer to the following conclusions, some of which are very different from those generally accepted at the present day.

A very important folding movement occurred in Queensland in Pre-Cambrian times. This was almost certainly synchronous with the Broken Hill movement in New South Wales, and is probably the local representative of the world-wide "revolution" which preceded the Cambrian period.

The great Cambrian transgression inundated a considerable portion of North-Western Queensland.

Certainly one, and possibly two, important orogenic movements occurred after the Pre-Cambrian movement and before Silurian times. One of these (developed in Northern Queensland) probably took place at the close of the Ordovician period. The other (developed in Southern Queensland) has not affected the lowest members of the Brisbane Schist Series of supposed Ordovician age, where typically developed.

Hence, if any reliability can be placed on the determination of the age of the Brisbane schists, the southern movement is older than the northern, but if, on the other hand, the Brisbane schists are younger than Ordovician the two movements may have been synchronous.

The evidence for regarding the Brisbane schists as Ordovician is admitted by all to be very weak (being based entirely on the presence of certain phosphatic veins similar to those found in rocks of known Ordovician age in New South Wales). Now, Richards and Bryan have shown that the upper portions of the Brisbane Schist Series are probably of Lower Devonian age and, as there is no sign of unconformity within the series, these presumably overlie rocks of Silurian age. The lowest (phosphatic) belt of the Brisbane schists may thus represent the Silurian period. This would harmonise with the fact that the Coff's Harbour schists of New South Wales, which are lithologically identical with the Brisbane schists, are mapped as of Silurian age. On the other hand, if the phosphatic belt does represent the Ordovician period, there is no sign within the Brisbane Schist Series of the particularly violent orogenic movement which closed the period in New South Wales, and which appears to be well represented in North Queensland. The removal of the Turquoise zone of the Brisbane schists from the Ordovician to the Silurian period would thus bring about a much more harmonious relation between the tectonic history of New South Wales and Queensland, and would enable us to explain the data with regard to the Lower Palæozoic movements in this State, in terms of one great movement at the close of the Ordovician period. Such an explanation is also in harmony with the tectonic history of the earth as a whole, for there appear to be no diastrophic events (not even minor events or "disturbances") between the Pre-Cambrian and the end of the Ordovician period. In Europe, indeed, this state of affairs persisted until the close of the Silurian period, but in North America the Ordovician (Cincinnattian) period closed with the important Taconic disturbance, which would thus synchronise with the Eastern Australian movement.

No orogenic movement of importance closed the Silurian period in Northern Queensland, and the evidence from the Brisbane Schist Series (whether the Turquoise zone be Ordovician or Silurian) supports this view. Here again, the tectonic history of this State appears to be more closely parallel with that of North America than with Europe, for although in the latter the Caledonian movement was very marked at this time it is practically unrepresented in the former. The record from Queensland is very different from that of New South Wales at this point, and this is somewhat disconcerting, as one might reasonably expect the two States to have a very similar history, as indeed they have with this one exception.

At the close of the Devonian period and (in places) during part of the Carboniferous period, there occurred in Queensland an orogenic movement of the first importance. The folding was intense and prolonged. This was the only great movement of folding between the end of the Ordovician period and the close of the Mesozoic era. It would be for the most part synchronous with, and is evidence in support of, the folding of the Kanimbla epoch in New South Wales. This movement was initiated when the great Caledonian movement of Europe was waning, and is thus more closely comparable with the Schickschockian disturbance of North America which separates the Devonian from the Mississippian, and which Schuchert regards as of equal importance with the earlier Caledonian and Taconic movements.

This movement also synchronises with the great folding movement of Abendanon's[245] supposed continent of "Æquinoctia," which folding is based largely on evidence from the Dutch East Indies and Southern Asia.

During Permo-Carboniferous times, gentle epeirogenic movements of uplift, alternating with subsidence, and terminating with uplift, took place as in New South Wales.

The movement succeeding the Permo-Carboniferous period was one of general epeirogenic uplift throughout Queensland.

As a result of the tension during and closely following the above uplift, numerous faults occurred and blocks of Permo-Carboniferous strata were dropped into the older and often highly folded formations below.

There was no folding of any importance in Queensland at the close of the Palæozoic era.

While this statement is in general agreement with the tectonic history of New South Wales, and indeed of all Australia, certain supposed exceptions should be considered at this point. Walkom[246] in 1918 made the following statements, which seem to reflect the general opinion :—" The close of the Palæozoic era in Northern New South Wales and Southern Queensland was accompanied by extensive intrusions of granitic masses. In the New England and Stanthorpe-Warwick districts these intrusions have resulted in extreme folding of the Permian strata but have not affected the sediments of the Walloon epoch. . . . The Permian sedimentary strata have been extremely folded and contorted and converted into slates resembling in general appearance rocks of greater age than Permian ; their age, however, has been fixed beyond doubt by the occurrence in them of marine fossils in the Drake district and near Warwick." " Further north, in the Gympie district, rocks of similar age are also folded and metamorphosed to much the same extent. . . ."

We have seen that in the Gympie area the only rocks of undoubted Permo-Carboniferous age, *i.e.* the Middle (or True) Gympie, are distinguished from the surrounding series, first by their gentle dip (22°) and secondly by the fact that they show no signs of regional metamorphism.

With regard to the area near Warwick, Richards and Bryan[247] have shown that the series actually containing the Permo-Carboniferous fossils (often most delicately preserved) is neither " extremely folded and contorted " nor metamorphosed ; and that, though sometimes the dips are moderately steep, no evidence of folding has been found. These Permo-Carboniferous beds are surrounded by a closely folded and steeply dipping (but only locally metamorphosed) series containing Devonian fossils.

The Drake and the Warwick areas have been so closely associated in all the arguments for folding in this area at the close of the Palæozoic era[248] that Richards and Bryan have suggested that the anomaly in the former area might be explained in the same way as in the latter area, especially as several other cases of block faulting of Permo-Carboniferous strata into highly folded older formations have been described from Northern New South Wales by Benson[249] and others.

With the disproof of strong folding in the Permo-Carboniferous strata of these areas, there would disappear the necessity for and the difficulty of explaining them as the result of the extensive intrusion of granitic masses (see Chapter X.).

Sussmilch[250] has described from the Gloucester district, in New South Wales, a narrow outcrop of Permo-Carboniferous coal measures elongate in a N.-S. direction, and enclosed between steeply dipping Carboniferous rhyolites. From the field evidence, Sussmilch reasons that "It would appear that the coal seams, like the surrounding Carboniferous strata, occur in the form of a plunging syncline," and concludes that "the close of the Palæozoic era was marked by orogenic earth movements on a grand scale, both the Carboniferous and Permo-Carboniferous strata were strongly folded and a series of high mountain ranges produced." This is difficult to reconcile with, and indeed must be regarded as evidence against, the general conclusions arrived at above.

So far the history of earth movements in Queensland has been closely comparable with that of North America, but the gentle movement of uplift which closed the era cannot be compared with the great "Appalachian Revolution" which there separates the Palæozoic and Mesozoic eras. Neither is it comparable with the great Armorican-Variscan-Hercynian-Pennine movements of Europe which took place about this time. Indeed there seems to be no other epoch of crustal disturbance in which the evidence from Eastern Australia, as interpreted by the writer, seems more at variance with the tectonic history of the earth as a whole.

But although the movement which ushered in the Mesozoic era was not accompanied by severe folding, this does not necessarily discount its importance, for movements of an epeirogenic nature usually affect vast areas, whereas those of an orogenic nature have a more or less limited and linear distribution. Even in those cases of folding which are definitely the result of orogenic processes, R. T. Chamberlin[251] has proved, from his careful measurements across folded mountains, that those which show gentle and open folding with normal faulting point to a much greater vertical uplift, and have affected much more deeply the earth's crust, than those which show intense folding and much overthrust faulting.

From the latter part of the Triassic period until late into the Cretaceous period, the dominating movement over the whole of Queensland was steady subsidence, broken by occasional pauses. Though such a statement will undoubtedly meet with general approval, it differs widely, as pointed out by Walkom,[252] from Schuchert's[253] interpretation of the tectonic history of Eastern Australia, for Schuchert states that during Jurassic and Cretaceous times the area was the scene of heavy folding.

This steady subsidence ended in an extensive transgression of the sea which deposited the Rolling Downs Series. The exact age of this transgression, whether or not there was more than one transgression, and the relationship which these bear to the eastern transgression under which the Maryborough Series was formed, are all problems which have yet to be solved. Andrews[254] taking the broad view, and basing his conclusions on one of the fundamental principles of disatrophism, would regard both the eastern and western transgressions as synchronous with the world-wide "Cenomanian" transgression which was so typical of Upper Cretaceous times. The palæontological evidence is very contradictory and can only be very briefly touched on here. The position as stated by Jack[255] in 1892 was as follows: "The fossils of the Rolling Downs formation have given rise to much controversy among geologists and palæontologists, who have pronounced various localities, from limited collections, to be of ages ranging from Rhætic up to Lower Chalk." Moore[256] in 1869 had concluded that it could be safely inferred that all the specimens examined by him from the Wallumbilla horizon of the Rolling Downs Series belonged to the Upper Oolite. Ten years later Tate[257] followed Moore in considering the fossils of the series of Jurassic age, but some years later (1888) Tate abandoned this decision, and, as the result of further evidence, concluded that the Lake Eyre fossils were of Cretaceous age, as contended by Jack. Etheridge[258] referred the Rolling Downs fossils collectively to the Cretaceous, although he admitted an admixture of Oolitic forms. Whitehouse has already been quoted as referring to two transgressions represented by the Rolling Downs Series, the earlier of which took place in Upper Aptian time, and a later in Upper Albian. The latter of these can be safely correlated with the great so-called Cenomanian transgression which, as is well known, was initiated some time before the Cenomanian strata were actually laid down.

The Maryborough beds were first considered, on palæontological evidence by Jack and Etheridge,[259] to be the equivalent of the Rolling Downs Series, but later they were elevated by these authors to the Desert Sandstone horizon. Since then they have been restored by Dunstan[260] to their old position of the eastern equivalent of the Rolling Downs Series, but Walkom[261] has urged that the flora of the overlying Burrum Series is of so distinctly a Lower Cretaceous type that the Maryborough Series may be of Jurassic age.

Very late in the Cretaceous period (but perhaps earlier in the Maryborough district than in Western Queensland) a general movement of elevation began, accompanied by folding, which shows its effect on every formation from Permo-Carboniferous to Cretaceous.

The absence of "disturbances" in Queensland during the greater part of the Mesozoic era, while identical with that of New South Wales, provides a very marked contrast with the tectonic histories of both Europe and North America, but the movement which closed the era in Queensland, though not nearly so intense, synchronises with the great Laramide Revolution of North America.

In Tertiary times a folding movement of much slighter intensity affected a restricted area.

In Late Tertiary times a general uplift (probably similar to that which closed the Palæozoic era) was initiated.

This was accompanied and followed by normal faulting, which produced step-like topography and graben (which again can be closely paralleled in late Palæozoic times).

This last great uplift, which closed the Tertiary era though of a radically different type, took place at the same time as the Cascadian Revolution, but, though we have no evidence of great Tertiary folding equivalent to the Alpine of Europe and the Cascadian of North America in Australia itself, such evidence is to be found in New Caledonia, which we have regarded as being structurally related to Australia.

Within recent times there has been a general subsidence of the eastern part of Queensland of approximately 200 feet. Still more recently there has been a slight uplift of about 15 feet along the whole coast of Queensland.

In looking back over this list it will be seen that the close of each era was marked by movements of the first order of magnitude, which resulted in widespread elevation. These movements correspond to the "major diastrophic events" or *revolutions* of the American authors, and are almost world-wide in their occurrence. In Queensland, these were not all of the same type, for while the Proterozoic and Mesozoic eras closed with movements of an orogenic type, the revolutions which closed the Palæozoic and Cainozoic eras approached the epeirogenic type of movement. In this, the tectonic history of Queensland seems to stand between Europe and America on the one hand, where the great movements closing the different eras were all of a markedly orogenic type, and Africa on the other hand, where (except in the far north) the epeirogenic type of movement has predominated since very early times.

Of the Palæogeography of Queensland before the Proterozoic movement one can say nothing, but it is significant that the other revolution of orogenic type was preceded by the greatest marine transgression in the history of Australia while the revolutions of epeirogenic type were preceded by continental conditions, at the end of the Palæozoic and Cainozoic eras respectively.

IX. THE AREAL DISTRIBUTION OF EARTH MOVEMENTS IN QUEENSLAND.

In this chapter it is proposed to consider the different directions of the more important trend lines, and their areal arrangement.

Although the study of palæogeography is necessarily and intimately related to that of tectonics, little space will be given here to palæogeographic problems, and that only to those of outstanding importance.

The trend of the present-day coast-line is usually regarded as having considerable significance as reflecting earth movements of some importance. This is not necessarily so, as it is universally admitted that the true edge of the continent is found at that sudden change of gradient at the edge of the continental platform which usually coincides with the 100-fathom contour. In many cases, as for instance that of New South Wales, this line is so close to and so consistently parallel with the coast-line itself, that deductions based on the direction of the one hold good for that of the other; but in that part of the world with which we are now concerned the direction of the Queensland coast is, for the greater part of its length, very different from that of the edge of the continental shelf. Hence, except for northernmost Queensland, it will serve no useful purpose comparing any but the more recent trends with the present coast-line, the proper line of reference being the 100-fathom contour. As an example of the writer's meaning one might take David's[262] statement that "The southern shore of the Gulf [of Carpentaria] seems related to the W.N.W.-E.S.E. fold axes which run through the Etheridge and Gilbert goldfields." The writer feels that the probability of the relationship of these very old trends to the present shore-line of the very shallow Gulf must be remote.

Shape of the Pre-Cambrian Continent.

Not very many years ago the eastern edge of the Pre-Cambrian forerunner of the present Australian continent was supposed to coincide with a N.W.-S.E. line from Victoria River in the Northern Territory to Wilson's Promontory in Victoria. This is well illustrated in a paper by Jensen[263] in 1910. Since this time the supposed outline of the Proterozoic continent has changed as the result of discoveries which necessitated additions to its northern portion, first by the inclusion of much of the Northern Territory, so that Andrews[264] in 1916 drew the supposed eastern boundary "from the south-west of Tasmania to the centre of North Queensland" but admitted that it was "possible . . . the land surface extended across the south-eastern [Cooma district] or even the eastern portion of the present continent," and lately by the addition of the Cloncurry area.

Jensen[265] would add Cape York Peninsula to the northern portion of the old continent, which portion he designates "the North Central Massif of Australia." With this supposed easterly extension of the continent the writer is in agreement, but he bases his conclusions, not on Jensen's arguments, with which he finds himself in disagreement, but mostly on the occurrence of gneisses and other very metamorphosed rocks with an ancient facies, in the Einasleigh area, and the fact that the trend of these rocks is parallel with the marked meridional trend of the metamorphic rocks of proved Pre-Cambrian age in the Cloncurry district. While Jensen's statement that "The North Central Massif of Australia is characterised by Archæan trend lines in a west-north-west direction" may hold good for the Northern Territory it certainly does not apply to Northern Queensland unless the Gilbert-Cape-River-Charters-Towers group of trends were caused by a Pre-Cambrian movement, and with this Jensen himself does not agree.

Whether the eastern coast of the continent should be represented by a straight line from the Einasleigh district to Tasmania, or should be thrown back in a deep concavity west of the MacDonnel and Musgrave Ranges as suggested by Jensen, or should be extended as an equally marked convexity to the east to include the old gneisses of the Normanby goldfield and Gatcombe Head, or even further east to include New Caledonia and

Fiji, are questions which cannot be decided until much more data are forthcoming. This much we may say : All the late discoveries have tended to elongate the Pre-Cambrian continent in an easterly direction and thus to bring it more in line with Schuchert's[266] well-known generalisation anent the "latitudinal arrangement of ancient lands."

One of the most important results arising from the recent discovery of Lower Cambrian fossils in almost horizontal strata in North-Western Queensland is the definite and valuable deductions which can thereby be made with regard to the tectonics of this area. For we now know with reasonable certainty, not only that a very important orogenic movement took place there along almost meridional lines in Pre-Cambrian times, but that *the area has never suffered from orogenic movements since that time.* In this respect (as in the great silver-lead deposits which it contains) the Cloncurry area may be closely compared with Broken Hill. If we join these areas by continuing the trends of each until they meet and then smoothing out the point of junction we should have a line convex to the east. To the west of this line we might expect to find, at depth, Pre-Cambrian rocks which have not been disturbed since Proterozoic times. Such a scheme would not explain the east-west folding of the early Palæozoic strata in Central Australia, but is, the writer thinks, to be preferred to that of Jensen, who, to explain the Central Australian structure, carries the coast of the Pre-Cambrian continent directly across the strongly marked trends of both the Cloncurry and Broken Hill areas, and shows over both these places (which, as we now know, both contain unfolded older rocks) an Ordovicio-Silurian Festoon of highly folded sediments.

The evidence from the supposed Pre-Cambrian rocks east of the Broken Hill-Cloncurry line (as near Einasleigh) suggests that, although quite violent movements in other directions took place long after the N.-S. trends were effected, these latter had been so firmly established in the Pre-Cambrian rocks that they resisted all later deformation.

The fact that the Cloncurry Series is folded about axes which run almost N.N.W. is an important one, on account both of the age and the geographical position of the series. This N.N.W. trend is all-important in the structural geology of Queensland, for, as we have seen, it is a common direction of folding and faulting from Pre-Cambrian to Post-Tertiary times and from North-Western to South-Eastern Queensland.

As R. T. Chamberlin[267] has recently pointed out, in criticism of Ruedemann's[268] conclusions regarding the shape and extent of "Archi-gondwana," it is difficult to reconcile a Pre-Cambrian continent of such a markedly E.-W. elongation, with the predominance of meridional strikes in the Proterozoic rocks. However, the fact that Chamberlin's own "Framework" hypothesis, while applicable to the other continents as they now exist, is admittedly weak when applied to Australia, is an argument for a former extension of the Australian continent rather than for restriction to its present size. Chamberlin's explanation of the Australian anomaly —that it represents "an abortive continent"—seems to the writer to be too fanciful for serious consideration.

Direction of Lower Palæozoic Trends.

The trend lines of supposed Lower Palæozoic age in Queensland fall naturally into three groups. One group in Cape York Pensinsula, of trends which strike a little west of north; a second group in the Etheridge-Cape-River-Charters-Towers belt, in which the strike varies from N.W. to W.S.W.; and a third group, for the most part to the south of the second, where the dominant strike is N.E.

Of these groups the second is made up of rocks of remarkably similar types. This is shown in the literature of the area, by the frequent comparisons made by the several geologists who have studied the area. Under these circumstances the writer has felt justified in connecting the strike lines in order to determine the general trend of this group, with the result shown in Fig. 1. This interpretation of the data differs from that of David,[269] whose map (Plate II.) shows two *conflicting* trends in the Gilbert area. The two strikes on which these trends were based were taken from places fifty miles apart, and when plotted on a large-scale map are easily reconciled as effects produced by *one* movement.

The third group differs in several respects from the second group, in that the individual occurrences are remarkably consistent in their north-easterly strike and are made of rocks which show great lithological diversity. The latter fact suggests that, in spite of the consistent trend, more than one period of folding is indicated. Although this N.E. trend group is most marked in the central portion of the State, representatives of it can be found as far south as Biarra and as far north as Pascoe River. The strong Pascoe River trends will surprise most geologists, for it has been quite naturally assumed from the elongate nature of the Cape York Peninsula, the trend of the coast and continental shelf, the trend of the mountain ranges, and the geological structure of the Hamilton and Coen goldfields, that the only trend represented in this area was slightly west of north.

Although a consideration of all the data has convinced the writer that the most important, most widespread, and most persistent trend line in the structure of Queensland, as of Eastern Australia generally, lies between N. and N.W., he is surprised that the important nature of the N.E. trend for Queensland has not been fully appreciated. That this direction is no mere local variation of the predominating N.N.W. strike will be shown by a glance at Fig. 1, and this is emphasized by the fact that the two are often found strongly developed in the same neighbourhood, in which case the north-easterly strike is usually the older.

It is a notable and probably significant fact that this N.E. trend is most strongly developed in that part of Queensland adjacent to the abnormally wide portion of the continental shelf which is here projected in a north-easterly direction. It is also known that parallel north-easterly trend lines actually pass through New Caledonia. The presence of these north-easterly trends in the old metamorphics of this island (in which all the newer rocks trend N.N.W.) which Suess[270] regarded as one of the three most puzzling features of the Melanesian arcs is thus simply explained if New Caledonia be regarded as part of an ancient Australian continent.

A still further continuation of these trends would serve to unite New Caledonia and Fiji in the manner suggested by Woolnough.

The fact that the tectonic history of New Zealand is bound up with the same two dominant trends (N.N.W. and N.E.) as those of Queensland is very significant, and shows that it is probably incorrect to regard New Zealand and Australia as structurally independent.

In New South Wales the old N.E. trends of Broken Hill stand in equally marked contrast with the newer N.N.W. trends of the New England district, but David[271] has shown that it is possible to regard them both as parts of one great system if we compare them indirectly through trend lines intermediate in direction found at Mount Brown, Mount Kosciusko, Canberra, Parkes, and Forbes.

Although there is ample evidence that the northerly trends of the Cape York Peninsula, the easterly trends of the Etheridge-Charters Towers group, and the north-easterly trend of the third group were all in large part the result of Pre-Silurian movement, their trends are so divergent that it is difficult to explain them in terms of one movement. The writer regards the second of these (the Etheridge-Charters Towers group) as being the most restricted both in time and space. In this he differs radically from Jensen, who, the writer thinks, very much over-emphasizes the E.-W. trends of Queensland. The remaining two are probably the result of much more important, more widespread, and more continuous earth movements of a conflicting nature, and resulting from forces directed from quite different directions. Both probably date from Pre-Cambrian times, but, while the N.E. trend was gradually restricted in space and had practically disappeared by the end of the Carboniferous, the N.N.W. trend was still strongly represented in folding movements up to the end of the Mesozoic era, and in faulting movements right up to the close of the Tertiary.

The writer has mentioned the " Ordovicio-Silurian Festoon" by means of which Jensen connects the Lower Palæozoic strata of the MacDonnel Ranges with their supposed equivalents in North Queensland. After investigating the evidence for this radical departure from general opinion the writer has concluded that, except for the fact that the MacDonnel Ranges strike east and west (the prolongation of which, by-the-way, would bring them to Central Queensland), and the probability that Pre-Cambrian rocks form a continuous floor from the Northern Territory to the base of Cape York Peninsula, the evidence is negligible. While the few Post-Cambrian strikes shown in his Fig. 2 lend an appearance of verisimilitude to Jensen's hypothesis, the writer is convinced, after consulting Jensen's own authorities, that these trends (in that portion of Queensland now under consideration) are misleading, and that the "grain" of the country in the Cloncurry region which he represents as E.-W. is a most decided and widespread N.-S. grain.

Direction of Upper Palæozoic Trends.

A consideration of the data collected in the earlier part of this paper shows that it is possible to express the directions of the Upper Palæozoic trends in terms of a few simple generalisations—a welcome contrast with the apparent confusion of data regarding the Lower Palæozoic movements. Thus in North Queensland, movements along both N.N.W. and N.E. lines are quite strongly represented. Throughout the rest of Queensland the folding has been along N.N.W. axes and seems to have been restricted to a belt running in a N.N.W. direction which belt appears to have coincided with the elongate geosyncline* in which the Devonian strata were deposited, the most notable departure from this rule being the abnormal strikes described by Ball, near the New South Wales border, which seem to call for some special explanation.

The intensity of folding seen in both the Devonian and Carboniferous formations is by no means uniform, but as one crosses the axis of folding from W.S.W. to E.N.E. the folding becomes more intense, which is also the case in New South Wales. Whether it is also correct to say that the folding becomes more recent is a debateable point. For while, for instance, the more intense folding of the Rockhampton beds as compared with the Drummond beds can be explained in this way, it can also be explained without introducing the time element. That the great orogenic movement which followed the Devonian period was a prolonged movement there can be little doubt, and that it was more intense in the east than in the west is also reasonably certain, but whether the movement travelled as a wave (as Andrews thinks is the case for New South Wales), or whether the more intense folding in the east was synchronous with the gentle folding in the west, the writer is not prepared to say.

It is also quite possible that the steep dips seen in the Rockhampton Series as developed in the type area were not produced by the late Devonian orogeny but resulted from a very much later movement, for Rockhampton lies on the northerly continuation of the most important of the great anticlines into which the Mesozoic strata have been folded (see Fig. 2). If such were the case one could say that the Carboniferous formations of Central Queensland have not participated to any marked extent in the folding movement which so compressed and foliated the Devonian and older series.

The writer sees no evidence whatever for Jensen's great "Devonian Festoon" which follows closely parallel to the Ordovicio-Silurian Festoon (which has already been considered) except the N.E. trend of the Devonian strata near the Broken River. Against Jensen's hypothesis is the fact that it would disconnect the Burdekin Series from the Cawarral-Raglan Series and the Silverwood Series, both of which Jensen places in a quite isolated geosyncline but to both of which the Burdekin beds are much more closely related faunally (being Middle Devonian) than they are with the Murrumbidgee Series (Lower Devonian) with which Jensen's "Festoon" unites them.

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* This geosyncline has a remarkably close parallel in the great Appalachian Geosyncline of North America. Both in their present geographical position, their age, their direction, and their relationship to the eastern, now vanished, borderlands of Appalachia and Tasmantis respectively, they are strikingly similar.

The Great Break in Trend between South-Eastern Queensland and New England.

One very important tectonic feature which the writer believes has never hitherto been recognised is the very marked break in trend between all those (Pre-Permo-Carboniferous) formations which have been affected by the late Devonian orogeny in South Queensland and their counterparts in Northern New South Wales. The fact that the break occurs near a State boundary probably explains in part why it has not been noted before, for any discordance between the New South Wales and the Queensland formations would naturally be considered merely a reflection of differences of opinion between the geologists of the two States. Another explanation is that the break is to some extent obscured by more recent deposits.

This break in trend is illustrated in Fig. 4, where the Pre-Permo-Carboniferous formations of Northern New South Wales are mapped in, just as they appear in the latest maps which the writer has been able to obtain. The Queensland portion of the map is based for the most part on the information contained in Dunstan's useful table of Queensland geological formations, being Appendix B of Harrap's School Geography of Queensland. As the formations are for the most part steeply dipping, their strikes can be determined with great exactitude and certainty, and their outcrops are usually elongate. The later strata and the igneous rocks have been eliminated from Fig. 4 as having no direct bearing on the question and being likely to obscure the issue.

The arguments in favour of a break at this point in the Ordovician or (as the writer thinks) Silurian strata may be summarised as follows :—

The Brisbane Schist Series in Queensland forms a distinct band, retains a N.N.W. strike parallel with the general direction of outcrop for a great distance, and appears to pass out to sea near Byron Bay. The Coff's Harbour Schists—although regarded provisionally as of Silurian age—have been declared by all who know both series to be identical, lithologically and structurally, with the Brisbane Schists. This series also strikes N.N.W., but though the two series are strictly parallel they are very much out of alignment. The northern end of the Coff's Harbour Schists is exactly opposite the southern end of the Brisbane Schists if considered along a line at right angles to the common strike. The distance from the western edge of the Brisbane Schists to the western edge of the Coff's Harbour Schists measured along this line is 150 miles.

The evidence for the break in the Devonian formation along the same line is as follows :—

The Silverwood Series near Warwick, though small in area, has a very definite and well-marked N.N.W. strike. This series has been closely correlated by Richards and Bryan with the Tamworth Series on the following evidence :—

(*a*) Similarity of general sequence.

(*b*) Marked similarity in lithological appearance of banded cherty shales and cherts.

(*c*) Presence of great numbers of Radiolaria in the banded rocks ;

(*d*) Presence of a very unusual and non-typical Devonian fauna with a very restricted vertical range in the Nemingha limestone in the Tamworth area, and in a lithologically similar limestone occupying the same relative position in the Silverwood Series ;

(*e*) Occurrence in each series on a restricted horizon of a curious rock in which fragments of fossiliferous limestone and of andesites are found together in an andesitic tuffaceous ground-mass.

The above details show that the correlation of the two series has been not merely general but detailed and strict, and that the only reasonable conclusion is that the Silverwood Series was once actually continuous with the Tamworth Series.

The Devonian of the Eastern Province of New South Wales, as mapped by Benson[272] as late as 1922, shows an elongate somewhat curved area with an approximately N.N.W. trend which represents what Benson considers had been a "geosynclinal region, which was not continuous to the north or to the south." This was written before the correlation with the Silverwood Series referred to above had been established, but Professor Benson now writes that he has no doubt as to the identity of the two series.

The Devonian of the Eastern Province have a consistent N.N.W. strike, and as mapped by Benson end suddenly where they are overlain by Mesozoic strata, but Benson has expressed his personal opinion as to their possible prolongation, by terminating the formation beneath the Mesozoic strata a short distance beyond the limit as actually mapped.

The same line of break in trend, drawn at right angles to the strike across the northern end of the New South Wales occurrence, crosses a prolongation of the Silverwood Series to the south at a distance of about 135 miles.

The Drake area (which, on quite other grounds than these, Richards and Bryan think may contain the equivalents of the Silverwood Series) lies just to the north of the line, and is also on the southern prolongation of the N.N.W. strike of the Silverwood Series.

The evidence for a lateral break in the Serpentine Belts of the two States is just as suggestive.

The writer has elsewhere in this address (Chapter X.) referred to the linear arrangement of Serpentine belts, and the intimate and causal relationship which seems to connect such belts with important orogenic lines. As the serpentine belts of both States may reasonably be assigned to the one great orogenic movement, any break in trend or lateral displacement should be well shown by the distribution of these rocks.

The Great Serpentine Belt of New South Wales as mapped by Süssmilch[273] shows that it forms a narrow steeply dipping horizon with a wonderfully persistent N.N.W. trend for over 130 miles.

The belt is abruptly terminated on the north at Warialda.

The Canoona-Cawarral, Kilkivan, and Pine Mountain serpentines, though they do not form a continuous belt and are not quite in alignment, are each associated with the late Devonian fold movement, and are situated on or near an important line of folding.

A line joining the Kilkivan and Pine Mountain occurrences and prolonged to the S.S.E. is closely parallel to, but far from being in alignment with, the Great Serpentine Belt of New South Wales.

The transverse line joining the Queensland and New South Wales belts at right angles to the common strike measures approximately 170 miles.

The Evidence of the Carboniferous Series.

We have noted that there is some difference of opinion, both in Queensland and New South Wales, as to the relationship of the Carboniferous to the Devonian strata. But that the Carboniferous strata of the New England area have been considerably folded with the underlying Devonian is generally admitted. The Rockhampton Series in Queensland seems to occupy a similar position, and differs in that respect from the less folded Drummond Series to the west and the Star Series to the north-west. This similarity in attitude, and the fact that it is the nearest series of Carboniferous rocks to the New England Belt, suggest that the two might perhaps be expected to show to some extent the effect of the sudden bending or lateral displacement which seems to have been so strongly impressed on the Devonian and older rocks. That this is so is indicated by the following facts :—

The sharp lateral displacement in the N.N.W. trending Carboniferous of New England as mapped by Süssmilch and David.[274]

This change in trend corresponds closely with the supposed line of lateral displacement already considered.

The marked change in strike from N.N.W. to direct E.W., noted by Ball in what he considers Carboniferous beds in Southern Queensland.

The Rockhampton-Eidsvold beds form a N.N.W. belt, and the strike of the rocks is also for the most part in that direction.

The supposed lateral displacement as measured across the strike from the neighbourhood of Narrabri to the southerly prolongation of the Rockhampton Series is approximately 130 miles.

In each case cited in support of the hypothesis there is no overlapping of the southern line with its northern counterpart, such as might reasonably be expected if the structure resulted from folding, and if the New South Wales occurrences represented the western limb of an anticline or syncline and the Queensland occurrences the eastern limb. The structure cannot be assigned to either a simple anticline or syncline, for the sequence of outcrops is in the same direction in each case.

The writer submits that, while there may possibly be other ways of explaining all these harmonious data, the most reasonable hypothesis is that a lateral displacement of all series older than Permo-Carboniferous has taken place after these beds have all been folded along N.N.W. axes, but before the deposition of the Permo-Carboniferous Series. This displacement has taken place at right angles to the strike and axes of folding. The amount of such displacement was very large and was approximately 150 miles. The evidence suggests further, that, while the Devonian and earlier rocks have been actually dislocated in the movement, the younger Carboniferous Series have been "stepped" across by a series of sharp bends but may not have suffered dislocation.

This great lateral displacement, at right angles to the trend of the axes of folding, is simply and readily explained in terms of the hypothesis of horizontal movement of geanticlines, which has of late received so much emphasis from the eminent structural geologist Brouwer.* [275] This authority has pointed out that while the vertical component of moving geanticlines is often exaggerated, the horizontal component has been neglected and ignored. Brouwer has supplied most satisfactory explanations of many apparent anomalies, in the otherwise linear arrangement of groups of islands, the presence of deep transverse straits across such lines, and other geographical phenomena in the islands comprising the Dutch East Indies, as expressions of the horizontal movement of the underlying geanticlines, and has lately applied the same hypothesis to explain the S-like curvature of the Central Atlantic Ridge. Brouwer has shown that the phenomena most closely associated with the sudden bends in the trends of orogenic axes are—(1) Transverse fractures and faults, (2) Abnormal strikes. The unequal lateral movements which give rise to such phenomena are, he thinks, the result of differential velocities in different portions of the moving geanticlines.

A point of interest in connection with the break in trend which we have been considering is that it coincides with one of the radiating tectonic gaps which Andrews[276] supposes to break across his great concentric series of earth-waves in the Australasian region.

The Close of the Palæozoic Era.

One frequently reads in Australian literature that the Permo-Carboniferous deposits of Queensland were laid down in a geosyncline, and many of the references imply, if they do not state explicitly, that this geosyncline was very narrow and almost trough-like in its nature. Griffith-Taylor[277] in particular has emphasized this supposed feature.

A brief study of the data available suffices to show that, as far as Queensland is concerned, such statements are far from the truth. In the first place, the main Bowen-Mackenzie-Dawson basin is, as we have seen, very wide and very shallow, and evidence has been adduced to show that gently dipping Permo-Carboniferous deposits have been found as far west as Hughenden, and are suspected to exist even in the Cloncurry district. Mr. L. C. Ball [278] has lately discovered them between Alpha and Jericho.

* See the series of articles in Koninlijke Akademie van. Wettenschappen te Amsterdam, vols. xxv. and xxvi.

They have been reported from the islands in the Gulf of Carpentaria, and are typically developed as far north as Cooktown and as far south as the New South Wales border. Such a distribution indicates the very widespread character of the Permo-Carboniferous sedimentation, and certainly does not support the idea of deposition in a trough-like geosyncline. Both the widespread development, and the alternation of shallow water marine sediments with coal measures, point to an extensive transgression alternating with lacustrine conditions. Such a transgression is in accordance with the history of Æquinoctia, of which Queensland is supposed to have formed a part.

The Permo-Carboniferous palæogeography thus resembles that of Upper Mesozoic times much more closely than it does that of the Devonian period with which it has been compared, where the deposits most probably *were* laid down in a geosyncline.

Direction of Upper Mesozoic Trends.

Although not nearly so intense, and differing in some other respects, the folding movement which closed the Mesozoic era has several points of resemblance with that which was initiated at the end of the Devonian period. The first of these is the direction of folding, for in both orogenic epochs the axes of folding were, for the most part, in an approximately N.N.W. direction. More than that, although the main axes of late Mesozoic folding were few in number and separated by wide intervals, one of them coincides for a considerable part of its length with the very important Serpentine line of the Post-Devonian movement. Such a close parallelism between the axes of folding, and coincidence in lines of weakness, is of course not surprising, for great folding forces might be expected to operate throughout long periods in the one direction, and once a plane of weakness has been formed in the earth's crust it is always likely to remain such. Suess[279] has emphasized this tendency towards repetition, and the consequent production of "posthumous" folds.

With regard to the distribution of intensity, the late Mesozoic movement again forms a close parallel with the Post-Devonian orogeny. In each case the intensity increases as we move across the strike from W.S.W. to E.N.E.

This marked areal distribution has quite often been interpreted as though it meant a similar time distribution, the age of the folding decreasing as we move across the strike from W.S.W. to E.N.E. Although this is a possible and indeed a generally accepted explanation of the structure it is not necessarily correct.

One frequently meets statements to the effect that, as one proceeds northwards along the Queensland coast, one sees evidence of more and more recent folding movements. Such statements may be true (but are not necessarily so) for that portion of the Queensland coast between the New South Wales border and Maryborough, for here the coast trends about N. 10° W., and as the folded Mesozoic strata strike about N. 30° W. this particular portion of the coast cuts very obliquely across them. Since the newer beds lie to the east of the older beds, one meets folded members of the different series in geological succession as one moves from south to north, but it is quite possible and indeed probable that they were all folded at the same time. But the same statements are obviously incorrect when applied to the Queensland coast as a whole. Compare, for example, the highly folded Cretaceous beds of Maryborough with the moderately folded Styx Cretaceous, and with the horizontal Cooktown Cretaceous. Indeed, if we leave New Guinea out of consideration as a quite independent structural unit, the very reverse of this generally accepted generalisation is true, and for the reason that most of the coast trends *more* than 30° to the west of north, and hence cuts obliquely across the Mesozoic trends, but this time in the other direction.

The correct generalisation is that frequently expressed by Andrews to the effect that, as one moves north and *east* (*i.e.*, almost across the dominant strike) one encounters younger and younger folded beds, because they are all conformable and dip on the whole to the north-east, but the inference which usually accompanies this statement, that the age of the folding movement is therefore younger and younger as one moves north-east, is not necessarily correct. Indeed the writer believes it to be quite incorrect, and holds that along the Queensland coast a folding movement at the close of the Mesozoic era folded all the formations from Permo-Carboniferous to the Burrum Series to much the same extent, and that this movement was not a protracted one, but on the contrary was of short duration.

The directions of the trends produced by this movement are shown by the anticlinal axes (which have been considered in some detail in an earlier chapter and which are illustrated in Fig. 2) to be along N. 30° W. lines.

X. RELATIONSHIP OF EARTH MOVEMENTS TO IGNEOUS ACTIVITY.

The theory that there is some causal connection between earth movements and igneous activity is almost as old as history itself, and finds unanimous acceptance in the scientific world of to-day. The relationship between tectonic and igneous activities is strikingly displayed, both in the very close parallel which can be traced in the geological histories of the two processes (alike for limited areas and for the earth as a whole) and in the similar areal distribution of the results of each class of activity. The parallel in time distribution gives igneous activity that periodicity, and natural expression in terms of cycles, which is one of the most marked characteristics of diastrophism, while the relationship in areal distribution is shown by a glance at any geological map of a reasonably large area. Although this relationship demonstrates itself in divers ways, its exact nature is often obscure, for while in exceptional cases it can be shown that igneous activity is the direct cause of earth movement, or *vice versâ*, in general the relationship is not a simple case of cause and effect, but rather of different effects related through a common cause. Hence many ingenious hypotheses have been invented to explain both sets of phenomena as the result of one set of mechanical processes.

Proterozoic and Lower Palæozoic Activity.

Associated with the very metamorphosed Pre-Cambrian Series of the Cloncurry district, with the supposedly Pre-Cambrian Series of the Einasleigh district, and with several of those other very old series which may be Pre-Cambrian but have in this address been regarded merely as Pre-Silurian, there are found granitic rocks of a very old facies. So intimate is the association of these granitic rocks with the sediments with which they are found, that many geologists have regarded the former as transmuted representatives of the latter. Thus Daintree[280] supposed the granites and schists of Charleston in the Etheridge district to be interbedded, and concluded that the granites were metamorphosed sediments. Rands[281] supported this view, and also held that a similar origin gave rise to the principal granites of the Croydon area. As late as 1920 Dunstan[282] wrote concerning the Cloncurry district: " The granites appear to be an extreme stage of metamorphism of the schists, with which they invariably conform in their trend. . . ." In many other places in the geological literature of Northern Queensland one comes across references to such "metamorphic granite" and descriptions of "schists grading into granites."

Other geologists, notably Cameron,[283] Marks,[284] and Jensen,[285] have detected the true, intrusive nature of the granites, and have expressed the opinion that the supposed interbedding is the result of intrusion of a *lit par lit* character.

Igneous activity of this puzzling nature is quite typical of Pre-Cambrian rocks in other parts of the world, where it is supposed to have resulted from intrusion during, or closely following, the intense orogenic movements of the Proterozoic era. Although the writer has not had the opportunity of studying these North Queensland occurrences in the field, the descriptions he has read vividly recall the Lewisian Series as examined by him in North-western Scotland.

Jensen[286] in 1923, after pointing out that it had always been the custom to regard the granites of Northern Queensland as all of Permo-Carboniferous age, divides them into two series, the " Older Granite" and the " Newer Granite." The former granites are largely gneissose in character, and are typically developed in the Einasleigh, Croydon, and Cloncurry districts. Jensen[287] wrote of the age of these granites (in 1920) that they were " probably Pre-Cambrian in age, or at the latest early Cambrian," and in a recent unpublished paper which the writer has been privileged to see Jensen[288] states: ". . . the granites of Croydon are true igneous rocks. . . . They are very old Pre-Cambrian granites as is the case with the granites of the Cloncurry massif." The Croydon granites Jensen supposes to " have been lowered into the zone of partial recrystallisation at some period in their history. . . . During their period of re-elevation from the deeper zones of the earth's crust strong thrust movements from the east and north-east caused a number of flat shear zones to form. . . ."

It seems highly probable on the evidence that, during or immediately after the great Pre-Cambrian movements in Northern Queensland, great intrusions of a granitic type resulted in an intimate and sometimes confusing complex of schistose and gneissose rocks.

The evidence also suggests that some of the metamorphic series which the writer has assigned tentatively to the Lower Palæozoic, such as the Cardross and Normanby occurrences, may also represent Pre-Cambrian rocks, possibly from a higher horizon than the Cloncurry Series.

No evidence of igneous action in the Cambrian period has been found in Queensland.

Of the Ordovician period in Queensland little is definitely known, but Jensen assigns his Herbertonian Series to this period, and considers it a time of steady sedimentation in North Queensland. He is also of the opinion that the chloritic schists, which make up a large part of the series, "possess the textural characteristics of metamorphosed volcanic tuffs" (presumably of a somewhat basic type). These suppositions are quite in accordance with the history of the Ordovician period in New South Wales, where, according to Sussmilch,[289] andesitic lavas and tuffs were poured out on a subsiding sea-floor. This again is in keeping with the similar vulcanicity of Ordovician times of England and Wales, which is anomalous in that it occurs in the middle of the "First Marine Period" of the English geologists.

Although, as we have seen, the evidence points to violent orogenic movements in Queensland, at the close of the Ordovician period, there is nothing to indicate the igneous activity which one would naturally expect to accompany such movements. A similar state of affairs seems to have existed in New South Wales, where all the evidence of igneous activity is that of the Upper Murrumbidgee, and Southern Tableland, plutonics which Andrews[290] very doubtfully assigns to this epoch as an alternative to Pre-Cambrian.

Middle Palæozoic Activity.

Jensen[291] describes the Silurian period in North Queensland as one of steady sedimentation, with much vulcanicity in the latter part of the period, and assigns much of the porphyries of North Queensland, including those of the Featherbed Range, to this period. Without attempting to discuss here the intricate "porphyry problem," as it has been called, the writer would point out that this view is opposed by some geologists. It is, however, quite in keeping with the history of the Silurian period in New South Wales.

It has been seen that there is no evidence of orogenic activity between the Silurian and Devonian periods in Queensland, and it is natural under these circumstances that no evidence of igneous action at this stage has been noted. Although a powerful, but somewhat irregular, movement is represented in New South Wales, it does not appear to have been accompanied by igneous activity, although the genesis of certain ore-bodies seems to have been associated with it. Although Jensen has described the Devonian period in North Queensland as one of steady sedimentation, and no vulcanicity, the latter part of his description certainly does not apply to Southern Queensland, where volcanic activity, albeit of a somewhat unusual type, is well represented.

The Spilitic Suite of the Silverwood Series.

Richards and Bryan[292] have described, from the Silverwood district, a suite of andesites, and andesitic tuffs, which in several respects have spilitic affinities. A world-wide characteristic of spilites is the problematical nature of their relationship to the sediments with which they are associated. Sometimes they appear to be definitely interbedded with the strata, and sometimes they appear to cut across them, so that different authorities have, in the past, come to quite different conclusions as to the intrusive or contemporaneous nature of occurrences of spilites, while some of the old investigators merely described what they saw, and refused to venture an opinion. The generally accepted hypothesis at the present day is that the spilites, while they may be in part submarine flows, are mostly very shallow intrusions into unconsolidated sediments. Hence, although strictly intrusive, the spilites are practically contemporaneous. The development of these strange rocks is held to have a distinct tectonic significance, as is shown by the following quotation from Benson:[293] "The rocks of the spilitic series as defined by Flett and Dewey, are also developed in areas in which there was an absence of folding forces during the period of eruption. They occurred, however, in geosynclinal areas that were undergoing steady subsidence in the period prior to an orogenic movement." These words describe exactly the sequence of events in the Silverwood area, but the writer would add some local details. After the intrusions and flows of the spilitic suite, there began a series of spasmodic submarine outbursts of a violently explosive type. Towards the top of the Silverwood Series the volcanic outbursts were less frequent, and the proportion of normal sedimentary material progressively increased. About the close of the Devonian period the area was subjected to an intense folding movement.

While a definite relationship thus appears to connect the spilitic suite at Silverwood with the great Post-Devonian orogeny which followed, an even closer relationship seems to exist between this movement and the serpentine belts of Queensland.

The Serpentine Belts of Queensland.

Associated with the Brisbane Schist Series, the Amamoor Series, and the Gladstone Series are respectively the Pine Mountain Serpentine, the Kilkivan Serpentine, and the Canoona-Cawarral Serpentine.[294] These serpentines have many points in common, most of which are also characteristic of the Great Serpentine Belt of New South Wales.

These are—(1) Their rather indefinite and puzzling relationship to the strata which they accompany, in which respect they resemble the spilites; in some sections they appear to be definitely intrusive into the strata while in others they appear to be interbedded with them. (2) In each case the serpentines show the development of marked schistosity. (3) They each occupy relatively the same horizon in the Brisbane Schist Series and its equivalents. This is so marked that, as we have seen, they form one of Dunstan's "Zones."

All these characteristics can be explained in the same terms as those in which Benson describes the great Serpentine Belt of New South Wales, with which, he thought, these Queensland occurrences could almost certainly be correlated, viz.—(1) The serpentines are intrusive; (2) They are for the most part concordant intrusions and thus usually form sills; (3) The intrusions took place while the intruded strata were undergoing intense folding movements accompanied by overthrust faulting.

The idea that ultrabasic intrusions were closely connected with earth movements of a certain type is, of course, not a new one, for Suess long ago enunciated the principle for the Alps that "green rocks form sills in dislocated mountains that sometimes follow the bedding planes and sometimes the planes of movement"; but Benson[295] as a result of his world-wide studies has, while placing the main idea on a sound basis, elaborated and extended it.

These results have an important bearing on this study, for it can be assumed with reasonable safety that serpentine belts mark important structural lines, and that their date of intrusion corresponds with an epoch of folding movement.

A study of the directions of the three Queensland belts of serpentine shows that the Pine Mountain-Fernvale serpentine strikes N.N.W. (the normal strike of the Brisbane Schist Series), and that it follows an important line of faulting and folding (on which considerable emphasis has been placed in an earlier portion of this address).

The Kilkivan serpentine belt strikes N. 10° W. This is neither quite parallel to nor quite in alignment with the Pine Mountain serpentine.

The Canoona-Cawarral serpentine strikes approximately N.W. Although this is both different in direction from and out of alignment with the Kilkivan occurrence, its position corresponds closely with a continuation of the same trend with which the Pine Mountain serpentine was associated.

We have seen that, though the evidence points to its being of the same age as the Queensland occurrences, the Great Serpentine Belt of New South Wales is far from being in alignment with them.

With regard to the age of the intrusion of the serpentine, and hence the age of the important folding movement with which they originated, the evidence is incomplete. Richards and Bryan[296] have shown that the Pine Mountain-Fernvale serpentine is closely associated with, and presumably intrudes, radiolarian jaspers very similar to the Woolamin (Lower Devonian) Series of New South Wales.

Of the Canoona-Cawarral serpentine, Dunstan[297] writes that fossiliferous (? Middle) Devonian limestones "rest on them." This, with the Fernvale evidence, would seem to fix the age of the serpentines as between Lower and Middle Devonian, but, from discussions with Mr. Dunstan and Mr. Willcox, one gathers that the relationship of the limestones and serpentines is not so simple as Dunstan's statement (which had necessarily to be very concise) indicates. Mr. Willcox tells the writer that the two rocks are intimately and confusedly related, fossil corals having been obtained from limestone within the serpentine belt. The limestone may thus have been earlier than the serpentine, which may then be Carboniferous in age. This would harmonise with Benson's[298] later estimates as to the age of the Great Serpentine Belt of New South Wales.

The serpentine belts of Queensland seem to be the only results, so far as igneous activity is concerned, of the very powerful orogenic movement which began with the close of the Devonian period, and the same statement is applicable to New South Wales.

Upper Palæozoic Activity.

Jensen[299] has described the Early Carboniferous as a time of violent folding and great granitic intrusions in Northern Queensland, but in a later publication[300] he writes of the "Newer Granites" of the Etheridge and Croydon districts:—"These granites have not undergone metamorphism. They are consequently of Carboniferous or later age—probably late Carboniferous." We have seen that Ball regards the granites of North Queensland as of Permian age. It seems certain that these Newer Granites *followed* the great Post-Devonian orogeny, and the writer is of the opinion that, like the granites of Southern Queensland, they were so late after the folding movement that they cannot reasonably be associated with it, but are more logically connected with the great epeirogenic uplift which closed the Palæozoic era.

In an earlier portion of this address, the writer opposed the generally accepted idea that the Permo-Carboniferous formations in the Drake, Silverwood, and Gympie areas had been very highly folded and metamorphosed by intruding granitic masses, on the score that the evidence that the strata *were* highly folded was very weak. The writer now submits that the granites show no sign of having been causally connected with any orogenic movement.

The most important evidence for the folding of Permo-Carboniferous strata comes, as we have seen, from the Gloucester district where there are no granitic masses.

Benson,[301] elaborating Harker's[302] well-known hypothesis of lateral differentiation as the result of pressure, points out that, while lateral pressure should bring about separations in the magma, and segregate those portions richer in the alkalies in those parts of the area where there is least lateral pressure, thus giving rise to marked petrological types, with restricted areal ranges, the converse should be equally true, and that where a magma has welled up into an area where there is no lateral pressure we should expect, after denudation, to find grouped together a whole succession of intrusions of increasing acidity, extending over a considerable period of time, as representing the normal products of differentiation.

This latter arrangement is well illustrated in New England, where the following sequence of intrusions has been worked out by Andrews[303] :—(1) " Grey Felspar Porphyry"; (2) "Blue and Black Porphyries"; (3) "Blue Granite"; (4) " Hornblendic, dioritic and other basic granites"; (5) " Coarse Acid Granites"; (6) " The Euritic Period "; (7) " Rhyolites, Quartz Porphyries, and Porphyries"; (8) " Intermediate to Basic Dykes." Here we have evidently a very good example of Brögger's "order of primary differentiation," which, as paraphrased by Harker,[304] is "an order of increasing acidity with in many instances a final reversion to basic types." In other words, the sequence as found in New England is precisely what we should expect, as the result of differentiation of a magma under conditions of no stress.

The writer has shown elsewhere[305] that Brögger's rule is also followed in the Stanthorpe and Enoggera areas.

David[306] has pointed out that the axes of intrusion of the great granite batholiths of New England differ in direction from the N.N.W. strike of the folded Palæozoics, and seem to sympathise with the trend of the adjacent coast-line and continental shelf. The axes of the granites are thus discordant with the *old pressure* directions of the Post-Devonian folding, and concordant with the *newer tension* directions, which ultimately determined the position of the present coast-line.

The investigations of Professor Richards and the writer have shown that, in the Silverwood-Lucky Valley area at least, the invading granite cuts across the strike of the Devonian rocks, and closely approaches the outcrops of one block of the infaulted Permo-Carboniferous sediments, without disturbing, in the slightest, the trend of either series. The only metamorphic effects are purely the result of heat and are restricted to the margin of the granite. In both the Devonian and Permo-Carboniferous Series numerous fossils in which delicate structures have been beautifully preserved have been collected.

Instead of the granites having been forced into the region, and having vigorously folded and metamorphosed the strata, all the evidence which the present writer has been able to collect suggests a quiet welling up into a region of tension. That the region was under tension, following gentle uplift at the time, is strongly suggested by the attitude of the infaulted blocks of Permo-Carboniferous strata which the field evidence indicates were let down into the underlying Devonian rocks shortly before the intrusion of the granite. Such a state of tension during Permian times was not limited to Queensland, for it was during the Permo-Carboniferous period that the dislocation of Æquinoctia began in the Dutch East Indies, and Schuchert[307] supposes the growth and expansion of the oceans to have commenced through the breaking down of the continents in Permian times.

The Permian granites of both North and South Queensland (as of Eastern Australia generally) differ markedly in one respect from the older (Proterozoic or Lower Palæozoic) granites, for, while the newer granites are frequently tin-bearing, the older never carry the tin group of minerals in commercial quantities, though they are often associated with gold.

This fact is so well known that the newer granites are frequently referred to as " The Tin Granites," to distinguish them from those of the older group. Andrews,[308] while recognising this fact, places very much more importance on the *areal* distribution of the Tin Granites, and concludes that the "group appears to mark the real limits of Australasia," and further, "a study both of structure and of ore deposits suggests that New Zealand, Australia and New Guinea have had independent origins." This conclusion is of such great importance that it may be well to examine it, if only briefly. If it be granted that the most fundamental facts in the geological structure of an area are indicated by the direction of its major trends (the grain of the country), and not by the age of the movements which have affected it, we may conclude that, while New Guinea with its predominating W.N.W. trend is structurally independent of Eastern Australia, both New Caledonia and New Zealand, where the two all-important trends are N.N.W. and N.E. (*i.e.*, identical in direction with the lines about which Eastern Australia has been moulded), are structurally related to it.

The grain of the three areas is identical, and the structural evidence thus suggests their unity rather than their independence. With regard to the evidence of the ore deposits, and particularly the areal distribution of the tin-bearing granites, on which Andrews lays so much stress, one admits readily that Andrews' hypothesis explains the facts of distribution in a simple way, and one that suggests the independence of Eastern Australia, New Caledonia, and New Zealand; but on the same line of reasoning one could argue that Western Australia and Eastern Australia were structurally independent, for it is not a fair assumption that the granites of the western portion of Australia have lost their tin as the result of the prolonged denudation which they have suffered, for, as Andrews points out, these old granites are often associated with very valuable deposits of ores other than those of the tin group. Now both Finlayson[309] and Rastall[310] (for Britain) and Spurr[311] (for America) have pointed out that, in the zonal deposition of ores accompanying the great granitic intrusions, the tin group occupies the lowest zone, and thus would be the *last* group to be lost by erosion.

The writer thinks that the distribution of the tin is most reasonably explained in terms of the fact that it is found in commercial quantities only in the newer Upper Palæozoic granites. These are not found in New Caledonia or New Zealand on the one hand or in Central and Western Australia on the other, but this does not necessarily imply structural independence, but only different times of igneous activity. It is a remarkable fact, and one which is true not only for the Australasian region but for the earth as a whole, that the granites which carry tin in commercial quantities are of Upper Palæozoic or Mesozoic age, the older granites being almost invariably barren in this respect even when geographically they are quite closely associated with newer granites. For the most part the tin granites of the world seem to have closely followed the great Hercynian, Armorican, and equivalent folding movements, of late Palæozoic times, the most important exception being the Tasmanian occurrences, which bear a similar relationship to Devonian movements. But even in Tasmania we find the earlier barren granites well represented. Ferguson and Bateman,[312] who made a special study of the " Geologic Features of Tin Deposits," came to the conclusion that although tin in different modes of occurrence was found in small quantities throughout geological history, " The periods of igneous intrusion at the close of the Carboniferous and during Mesozoic times seem to have been particularly favourable for the tin-bearing granites." This combination of wide areal distribution and limited time range of the tin granites has, the writer thinks, like the widespread occurrence and high percentage of titanium in basalts of Tertiary age, an important petrogenic significance.

Volcanic Activity of the Permo-Carboniferous Period.

Professor Richards,[313] who has recently reviewed our knowledge of the Volcanic Rocks of Queensland, has pointed out that there is a wide distribution of volcanic rocks of Permo-Carboniferous age along the coastal strip of Queensland and up to 150 miles or more inland, and he has also noted that this volcanic activity was specially pronounced in the Lower Bowen stage, the most important exception being the Silverwood volcanics. The same authority has expressed doubt as to "whether due appreciation of the great volcanic activity of the early part of the Permo-Carboniferous period has been felt by Australian geologists." Jensen[314] has made the statement that "the lavas were all of an intermediate to basic nature," but Richards disagrees with him, and points out that dacites and rhyolites play a dominant part in the volcanic accumulations. Several occurrences suggest to the present writer that we may, with fuller knowledge of these volcanics, find that those associated with the lower dominantly marine stage are of an andesitic nature, while those found with the upper freshwater strata are of a rhyolitic facies.

An interesting example of the relationship between tectonics and igneous activity has been described by Richards and Bryan,[315] from the Silverwood-Lucky Valley area of South-Eastern Queensland.

As the result of the " Hunterian disturbance" of Sussmilch and David,[316] the Silverwood area was depressed below sea-level, and fossiliferous strata equivalent to the Lower Marine of the Hunter River district were deposited. These seem normal sediments, for the most part laid down under shallow water, and show no signs of violent contemporaneous activity such as that which Andrews[317] described as accompanying the accumulation of sediments of this age, in the Drake area some 50 miles to the south of Silverwood. A slight change in sea-level resulted in the deposition of freshwater sediments equivalent to the Greta measures. Following this, the area seems to have been subjected to a series of oscillatory movements, with the result that, while the major portion of the sediments deposited were marine in nature (though of very shallow water types), there are intercalated with them bands of freshwater deposits. The net result of these oscillations was a gradual change from marine conditions to terrestrial conditions, and it was during this change that volcanic activity became manifest, for, while a considerable proportion of the lavas and tuffs are found associated with fossiliferous marine strata, the major portion of them shows evidence of having been extruded on to a land surface. This volcanic activity was of a notably acidic character in the earlier and more vigorous phases, but as the region became more permanently terrestrial the volcanic products decreased in amount and also in acidity, the last representative being a basalt of limited thickness and extent. These Permo-Carboniferous volcanics may reasonably be regarded as the first phase of a typical igneous cycle, the main event of which was the intrusion of the great granitic batholiths of New England and South-Eastern Queensland, following an epoch of uplift and tension. Such a supposition is supported by the fact that chemical analyses of the volcanic rocks, though unlike the typical tin-bearing granites of the area, are remarkably like the earlier granodiorites (the "Grey Phase" granites of the present writer[318]), which are also well represented in the area. The cycle was completed, as we have seen, by the intrusion of numerous dykes of a rhyolitic nature with a final reversion to basic types.

Mesozoic Activity.

The only evidence of igneous activity during the Triassic period is in South-Eastern Queensland, where the Brisbane Tuff is found lying almost at the base of the Ipswich Series and where Reid and Morton[319] have described an "Andesitic Stage" from the base of the Esk Series.

While no igneous rocks of definitely Jurassic age have been reported from Queensland, there have been observed, in the southern part of the State, occurrences of plutonic, hypabyssal, volcanic, and pyroclastic rocks which have been described as of Mesozoic age. Thus Jensen[320] writes, "It is my opinion that while most of the basic intrusives in the belt extending from Biggenden to Gayndah are Palæozoic, the rhyolites, dacites, quartz porphyries, and granites are in the main Mesozoic," and "I have also come to the conclusion that in the Mundubbera-Hawkwood district we have granites of two ages—viz., an older Devonian or Carboniferous granite and a later Mesozoic granite."

Certain field investigations which the writer has recently made in company with the Rev. C. H. Massey, in the area between Biggenden and Maryborough, shed some light on the age of the igneous rocks in this area, and on their relationship to the tectonics of the area. A detailed account of the investigations and conclusions is in course of preparation, but those facts which are relevant to the question under discussion may be briefly stated.

The Tiaro Series is generally recognised as equivalent to the Walloon Series (but Jensen[321] regards it as of Ipswich age). It conformably underlies the Maryborough Marine Series and is of great thickness (the late Captain

L. R. Blake, M.C., and the writer estimated it as at least 12,000 feet). Massey and the writer find that the Tiaro Series, so called, is naturally divisible into four series as follows :—

Tiaro Series in Old Sense	Graham's Creek Series. Andesitic and Rhyolitic Tuffs and Flows.	Volcanic Series
	Tiaro Series = Walloon Series, Shales and Coaly Shales. *Cladophlebis*.	Intruded by Porphyrites.
	Myrtle Creek Series = Bundamba Series. Massive current bedded sandstone. Barren.	Invaded by great granitic intrusions.
	Brooweena Series = Ipswich Series. Shales and Sandstones. *Thinnfeldia*.	

Great granitic intrusions, one of which measures at least five miles in diameter, intrude and metamorphose both the Brooweena Series and the overlying Myrtle Creek Series, but may be older than the Tiaro Series (in the restricted sense). On the other hand the attitude of the Mesozoic strata in the neighbourhood suggests that the intrusion post-dated their folding—*i.e.*, that the intrusion took place in late Mesozoic or even early Tertiary times, but, in the absence of more detailed evidence, the writer will not urge such a radical hypothesis. Numerous porphyrites intrude the Tiaro Series. Above the Tiaro Series proper, and forming passage beds between them and the Maryborough Marine, is the Graham's Creek Series, composed almost entirely of andesitic, trachytic, and rhyolitic tuffs, and possibly interbedded flows. These are conformably overlain by the Maryborough Marine Series.

While the great granitic and lesser porphyritic intrusions appear to have taken place during slow but intermittent subsidence, the eruption of the volcanics of the Graham's Creek Series coincided with the reversion from terrestrial and lacustrine conditions (which had persisted since late Palæozoic times) to marine conditions of deposition.

The igneous rocks of the area thus appear to form a cycle—though perhaps not of the normal type—of calc-alkaline rocks.

The writer knows of no parallel in Australia with the Graham's Creek Series of volcanics, whether the series be of Jurassic age (as suggested by Walkom's palæontological evidence from the older Walloon and younger Burrum Series) or of Cretaceous age (as the fossils of the Maryborough Marine Series would indicate), but Benson[322] states that in New Caledonia Upper Jurassic and Lower Cretaceous times were characterised by subsidence, sedimentation, and the extrusion of rhyolites and andesites.

Kainozoic Activity.

During the Kainozoic era, Queensland (and Eastern Australia generally) was the scene of very vigorous and prolonged volcanic activity. The Tertiary volcanics of South-Eastern Queensland have been studied in detail by Richards,[323] while the same authority has recently summarised our knowledge of the Tertiary activity throughout the State, and has also discussed the relationship of the volcanic rocks to the Tertiary earth movements.[324] Richards finds that the Tertiary volcanics of South-Eastern Queensland fall naturally into three series—(1) A Lower, made up of normal and olivine basalts, (2) A Middle, of rhyolites, trachytes, and associated tuffs; (3) An Upper, of basalts, andesites, and olivine basalts. These three series appear to be the equivalents of similar tripartite divisions for both New South Wales and Victoria, and since these latter are spread throughout practically the whole of Tertiary times, it is reasonable to assume the same for the Queensland occurrences. Thus the Lower Group is probably of Lower Kainozoic, the Middle of Middle Kainozoic, and the Upper of Upper Kainozoic age respectively. Many observers have, however, noticed that in North Queensland the latest flows were very recent indeed, and are almost certainly younger than those of Southern Queensland.

With regard to the nature of the vulcanicity and its relation to earth movements, Richards (*op. cit.*) will be quoted at some length :—

> " Extrusions both from fissures and central vents have taken place and generally speaking fissure eruptions were responsible for the Lower and Upper effusions while the most acid and viscous material of the Middle division was erupted through central vents.
>
> " The area of Southern Queensland was a calc-alkaline or sub-alkaline province during the Cainozoic era but during the middle portion of the era several small alkaline sub-provinces arose.
>
> " Rhyolites, trachytes, dacites, andesites, and basalts have been recognised, but the law of increasing divergence for the order of effusions has been well maintained.
>
> " The area during the Cainozoic era has not been affected by any folding movements, but there is distinct evidence that at least three very heavy faults have been developed.
>
> " Harker's generalisation that calc-alkaline rocks are associated with folding earth movements is not borne out in this area.
>
> " Daly's hypothesis as to the origin of alkaline rocks also fails to find support in this region, as calc-alkaline and alkaline rocks appear to have been extruded from the same eruptive centre."

After stating that " Woolnough and Wearne have given good evidence of block faulting along the Main Range near Cunningham's Gap," Richards proceeds—

> " It is interesting to note that along this line of the Main Range there has been very great volcanic activity including both calc-alkaline and alkaline outpourings while the axial prolongation of one of the lines of faulting passes through Mount Flinders and its associated peaks of alkaline trachyte material.
>
> " Jensen, in discussing the alkaline rocks of Southern Queensland, indicated that in Tertiary times a fault developed and the country west of it was progressively raised and that east of it was depressed ; ' simultaneously outpourings overspread the plains on both sides of the fault.' Jensen is further quoted as saying ' The trachytes of South-eastern Queensland appear to have extruded from a line of fracture separating adjacent earth segments undergoing differential uplift or subsidence.' "

Concerning the Tertiary basalts of the Cooktown district, Ball[325] makes the interesting observation that they " have probably a genetic relationship with the Cook uplift, during which the Trias-Jura beds along the coast were elevated more than 1,000 feet." Another observation by Ball[326] in the same area was that " The frequent occurrence of these basic volcanics along the valley bottoms and among the mesas along the inner edge of the coastal lowlands is suggestive of the volcanic activity having been due to the production of canons and mesas, with consequent disturbance of the isogeotherms and weakening of the crustal arch, but at the same time it is probably genetically connected with extensive fissuring brought about during the Cook uplift."

After reviewing all the evidence Richards concludes that—

> " It is clear from the above that in Queensland especially in the south-eastern and northern portions great lava floods have welled up through fissures where rifts ranging generally north and south have been attended by deep crustal faulting and sinking.
>
> " Both the calc-alkaline and alkaline lavas have been poured out under similar conditions as to rifting and sinking as far as one can ascertain, but there is a marked tendency for the alkaline lavas to be associated with central eruptions along the lines of fissure, but this no doubt is the result of the higher viscosity of the trachytic magmas."

Summary of Earth Movements and Igneous Activity.

1. The supposed Pre-Cambrian folding of North Queensland is intimately associated with the intrusion of non-stanniferous granites.

2. Neither the supposed heavy folding following the Ordovician period, nor the known heavy folding following the Devonian period, were, so far as is known, associated with granitic intrusions.

3. The epeirogenic uplift which closed the Palæozoic era was followed, after an interval of tension and block faulting, by the important stanniferous granites of New England and Queensland. These formed part of a normal igneous cycle, and show a sequence of rock types typical of normal differentiation.

4. Although the earth movements which preceded them are of a very different type, these stanniferous granites have their counterparts in the tin-bearing granites of Europe and other parts of the world, but not in North America.

5. In the most easterly portion of Queensland, granodiorites were intruded into Upper Triassic strata, but may have preceded by a considerable interval the Late Mesozoic orogeny in this area. The granodiorites form part of an abnormal (but not unusual) igneous cycle—viz., Plutonic-Hypabyssal-Volcanic—and show no sign of differentiation, being dominantly calc-alkaline.

6. These, the youngest and most restricted plutonic rocks in Australia, afford striking support of Andrews'[327] generalisation that "the Plutonics associated with periods of orogenic activity are arranged in belts which, as time progressed, contracted in area in directions from west to east and from south to north."

7. The great Post-Devonian orogenic movement was preceded by the effusion of a suite of flows and tuffs of a spilitic nature, and was accompanied by great sills of serpentine.

8. Several epochs of subsidence, accompanied by volcanic flows and tuffs of an andesitic type, support in a general way Jensen's[327] generalisation for Queensland that "Andesite indicates a subsiding and rhyolite a rising area." These are—(1) The (?) Ordovician of North Queensland; (2) the Devonian of South Queensland; (3) the beginning of the Permo-Carboniferous; (4) the end of the Jurassic in the Maryborough district.

9. The late Permo-Carboniferous movement of elevation, which was accompanied both in North and South Queensland by volcanic activity of acidic type, supports the latter part of Jensen's generalisation.

10. The tension and faulting which accompanied and followed the Tertiary epeirogenic uplift was accompanied throughout the eastern portion of the State by great volcanic activity, which was principally of a basic nature, but in which "the law of increasing divergence for the order of effusions has been very well maintained."

SUMMARY OF EARTH MOVEMENTS IN QUEENSLAND.

Time.	Type.	Intensity.	Area Affected.	Trend.	Direction of Force.	Geographical Result.	Igneous Activity.
Pre-Cambrian	Sedimentation	..	North-west and (?) North	..	..	Sea in N.W. and (?) N.	
	Folding and Elevation	V. Great	North-west and (?) North	N. 10° W.	From W.	Land in N.W. and (?) N.	Great granitic intrusions
	Subsidence	..	North-west and (?) North	..	..	Extensive transgression	
Cambrian	Sedimentation	..	North-west	..	..	Sea in N.W.	
	Uplift	..	North-west	..	..	Land in N.W.	
	and Subsidence	..	North	..	..	Geosyncline in East	
Ordovician	Sedimentation	..	North (?) Central (?) Sth. Coast	..	..	Sea in N. and E.	Andesitic lavas and tuffs
	Folding and Elevation	V. Great	North (?) Central (?) Sth. Coast	N.N.W. W.N.W. N.E.	From W. (?) From N. From N.W. (?)	Land general	
	Subsidence	..	North Coast (?) Central (?) Sth. Coast	..	..	Geosyncline in E. and (?) Sea in N.W.	
Silurian	Sedimentation	..	North Coast (?) Central Coast (?) South Coast	..	..	Geosyncline in E. and (?) Sea in N.W.	(?) Acid volcanics in N.
Devonian	Sedimentation	..	East	..	..	Geosyncline in E. and (?) Sea in N.W.	Submarine eruptions of andesitic and spilitic lavas, &c.
	Folding	Great	East	N.N.W. N.E.	From E. From S.E. (?)	E. Sea partly drained	Sills of serpentine
Carboniferous	Sedimentation	..	East and Centre	..	..	Sea more extensive but shallower	
	Folding	Moderate	Central Coast (?) South Coast	N.N.W. N.E.	From E. From S.E. (?)		
	Subsidence	..	General	..	..	Sea more extensive but shallower	Great andesitic vulcanicity

Permo-Carboniferous	Gradual uplift with intermittent subsidence	..	General				
	Uplift	..	General.. ..	..	..	Widespread lakes followed by general land	Great acidic vulcanicity
	Sagging and trough faulting	..	General.. ..	..	..	Rift valleys formed ..	Great Granitic intrusions
Triassic	Restricted lacustrine sedimentation	..	South-east ..	..	..	Land general but lakes in S.E.	Rhyolitic and andesitic activity in S.E.
	Gradual and intermittent subsidence	..	General.. ..	..	..	..	Granodiorites E. centre
Jurassic	Extensive lacustrine sedimentation	..	General.. ..	..	..	Lakes much more extensive and general	
	Gradual and intermittent subsidence	..	General.. ..	..	..	Lakes much more extensive and general	Intrusion of porphyrites
Cretaceous	Extensive marine sedimentation	..	General.. ..	..	..	Widespread transgression. Sea over most of Qld.	Andesitic tuffs, E. centre
	Folding and elevation ..	Moderate ..	{Central Coast / South Coast}	N. 30° W.	From E. ..	Land general with restricted lakes	Extensive basaltic flows. Many acidic volcanics
Tertiary	Limited lacustrine sedimentation	Heavy ..	East	N.N.W.	..	Few lakes centre and S. Coast	Widespread basaltic flows
	Faulting and folding ..	Gentle ..	Central Coast ..	N. ..	..	Land general	
Recent	Subsidence and faulting ..	About 200 ft.	Coast	N.N.W...	..	Drowning of coastal strip ..	Basaltic flows in N.
	Uplift	About 15 ft...	Coast	..	..	Low coastal plains formed	

SUMMARY OF EARTH MOVEMENTS IN QUEENSLAND.

Time.	Type.	Intensity.	Area Affected.	Trend.	Direction of Force.	Geographical Result.	Igneous Activity.
Pre-Cambrian	Sedimentation	..	North-west and (?) North	..	..	Sea in N.W. and (?) N.	
	Folding and Elevation	V. Great	North-west and (?) North	N. 10° W.	From W.	Land in N.W. and (?) N.	Great granitic intrusions
	Subsidence	..	North-west and (?) North	..	..	Extensive transgression	
Cambrian	Sedimentation	..	North-west	..	..	Sea in N.W.	
	Uplift	..	North-west	..	..	Land in N.W.	
	and Subsidence	..	North	..	..	Geosyncline in East	
Ordovician	Sedimentation	..	North (?) Central (?) Sth. Coast	..	..	Sea in N. and E.	Andesitic lavas and tuffs
	Folding and Elevation	V. Great	North (?) Central (?) Sth. Coast	N.N.W. W.N.W. N.E.	From W. (?) From N. From N.W. (?)	Land general	
	Subsidence	..	North Coast (?) Central (?) Sth. Coast	..	..	Geosyncline in E. and (?) Sea in N.W.	
Silurian	Sedimentation	..	North Coast (?) Central Coast (?) South Coast	..	..	Geosyncline in E. and (?) Sea in N.W.	(?) Acid volcanics in N.
Devonian	Sedimentation	..	East	..	..	Geosyncline in E. and (?) Sea in N.W.	Submarine eruptions of andesitic and spilitic lavas, &c.
	Folding	Great	East	N.N.W. N.E.	From E. From S.E. (?)	E. Sea partly drained	Sills of serpentine
Carboniferous	Sedimentation	..	East and Centre	..	..	Sea more extensive but shallower	
	Folding	Moderate	Central Coast (?) South Coast	N.N.W. N.E.	From E. From S.E. (?)		
	Subsidence	..	General	..	..	Sea more extensive but shallower	Great andesitic vulcanicity
Permo-Carboniferous	Gradual uplift with intermittent subsidence	..	General				
	Uplift	..	General	..	..	Widespread lakes followed by general land	Great acidic vulcanicity
	Sagging and trough faulting	..	General	..	..	Rift valleys formed	Great Granitic Intrusions
Triassic	Restricted lacustrine sedimentation	..	South-east	..	..	Land general but lakes in S.E.	Rhyolitic and andesitic activity in S.E.
	Gradual and intermittent subsidence	..	General	..	..	..	Granodiorites E. centre
Jurassic	Extensive lacustrine sedimentation	..	General	..	..	Lakes much more extensive and general	
	Gradual and intermittent subsidence	..	General	..	..	Lakes much more extensive and general	Intrusion of porphyrites
Cretaceous	Extensive marine sedimentation	..	General	..	..	Widespread transgression. Sea over most of Qld.	Andesitic tuffs, E. centre
	Folding and elevation	Moderate	Central Coast South Coast	N. 30° W.	From E.	Land general with restricted lakes	Extensive basaltic flows. Many acidic volcanics
Tertiary	Limited lacustrine sedimentation	Heavy	East	N.N.W.	..	Few lakes centre and S. Coast	Widespread basaltic flows
	Faulting and folding	Gentle	Central Coast	N.	..	Land general	
Recent	Subsidence and faulting	About 200 ft.	Coast	N.N.W.	..	Drowning of coastal strip	Basaltic flows in N.
	Uplift	About 15 ft.	Coast	..	..	Low coastal plains formed	

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ABBREVIATIONS.

A.A.A.S. ..	Australasian Association for the Advancement of Science.
Fed. B.A.A.S. ..	Federal Handbook, British Association for the Advancement of Science, 1914.
N.S.W. B.A.A.S.	New South Wales Handbook, British Association for the Advancement of Science, 1914.
G. of Q... ..	Geology and Palæontology of Queensland and New Guinea, 1892. (Jack and Etheridge.)
Q.G.S.P. ..	Queensland Geological Survey Publications.
Q.G.M.J. ..	Queensland Government Mining Journal.
P.R.S.Q. ..	Proceedings of the Royal Society of Queensland.
P.R.S. N.S.W...	Proceedings of the Royal Society of New South Wales.
P.R.S. W.A. ..	Proceedings of the Royal Society of West Australia.
P.R.S.T. ..	Proceedings of the Royal Society of Tasmania.
P.L.S. N.S.W...	Proceedings of the Linnean Society of New South Wales.
N.S.W. G.S.R.	Records of the Geological Survey of New South Wales.
Geog. of Q. ..	Appendix B in Harrap's Geography of Queensland, 1916.
Mem. Qld. Mus.	Memoirs of the Queensland Musuem.
Q. Geog. J. ..	Queensland Geographical Journal.
G. of N.S.W. ..	Geology of New South Wales. (Süssmilch.)
Bull. N.T. ..	Bulletin of the Northern Territory.
T.N.Z.I. ..	Transactions of the New Zealand Institute.
Q.J.G.S. ..	Quarterly Journal of the Geological Society.
Geol. Mag. ..	Geological Magazine.
J. of G. ..	Journal of Geology.
Am. Jour. Sci.	American Journal of Science.

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93. G. of Q., p. 88.
94. Q.G.M.J. 1918, p. 10.
95. Q.G.M.J. 1918, p. 9.
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99. Q.G.S.P. No. 256, pp. 60 and 65.
100. G. of Q., p. 36 *et seq.*
101. G. of Q., p. 7 *et seq.*
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104. Q.G.S.P. No. 274, fig. 13.
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106. G. of Q., p. 114.
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113. Geol. Features, Silver Valley.
114. Q.G.M.J. 1924, p. 80.
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117. G. of Q., p. 97.
118. G. of Q., p. 138.
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121. Verbal communication.
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125. Q.G.M.J. 1925, p. 5.
126. Q.G.M.J. 1925, p. 8.
127. Q.G.S.P. No. 155, p. 17, pl. i.
128. Q.G.S.P. No. 239, p. 7.
129. Q.G.M.J. 1925, p. 10.
130. Q.G.M.J. 1916, p. 433, fig. 1.
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132. Q.G.M.J. 1922, p. 225.
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134. Q.G.M.J. 1924, p. 48.
135. G. of Q., p. 128.
136. Q.G.S.P. No. 235, p. 21.
137. Q.G.M.J. 1914, p. 412.
138. Q.G.S.P. No. 254, p. 21.
139. Q.G.S.P. No. 258, p. 5.
140. Q.G.S.P. No. 235, p. 19.
141. Q.G.M.J. 1921, p. 10.
142. Q.G.S.P. No. 232, p. 16, fig. 1.
143. G. of Q., p. 175.
144. P.R.S. N.S.W. 1911, p. 47.
145. Q.G.M.J. 1917, p. 449, fig.
146. Q.G.S.P. No. 237, p. 14, fig. 2.
147. Q.G.S.P. No. 237, p. 13.
148. Q.G.S.P. No. 52, p. 3.
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154. P.R.S.Q. 1924, p. 80.
155. Q.G.M.J. 1918, p. 155.
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157. Geog. of Q., p. 170.
158. G. of Q., p. 171.
159. G. of Q., p. 95.
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170. Q.G.S.P. No. 272 (pref. note).
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172. P.L.S. N.S.W. 1918, p. 100.
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177. Q.G.M.J. 1922, p. 185.
178. P.L.S. N.S.W. 1923, p. 155.
179. Q.G.M.J. 1921, p. 407.
180. Geog. of Q., p. 166.
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186. Q.G.M.J. 1921, pp. 404 and 406.
187. P.R.S.Q. 1924, p. 144.
188. Q.G.M.J. 1922, p. 432 *et seq.*
189. Q.G.M.J. 1923, p. 245.
190. Q.G.M.J. 1905, p. 459.
191. Q.G.S.P. No. 147, p. 2.
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195. Qld. Min. Index, pls. iii. and v.
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197. A.A.A.S. 1913, p. 179 *et seq.*
198. Q.G.S.P. No. 262 (Geol. Note).
199. N.S.W. B.A.A.S., p. 574.
200. P.R.S.Q. 1924, p. 144.
201. P.R.S.Q. 1915, pt. 2, p. 163.
202. P.R.S.Q. 1915, pt. 2, p. 114.
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204. P.L.S. N.S.W. 1918, p. 63.
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209. Q.G.S.P. No. 249, p. 9.
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213. Q.G.S.P. No. 253, p. 8, fig. 3.
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218. Q.G.M.J. 1918, p. 57.
219. P.R.S. N.S.W. 1910, p. 474.
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221. P.R.S. N.S.W. 1911, p. 140.
222. P.R.S.Q. 1915, pt. 2, p. 113.
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244. N.S.W. G.S.R., vol. vii. p. 211.
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246. P.L.S. N.S.W. 1918, p. 96.
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260. Geog. of Q., p. 166.
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312. Economic Geology 1912, p. 213.
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314. P.R.S.Q. 1911, p. 159.
315. P.R.S.Q. 1923, p. 122.
316. P.R.S. N.S.W. 1919, p. 282.
317. N.S.W. G.S. Min. Res. No. 12, p. 11.
318. P.R.S.Q. 1922, p. 148.
319. Q.G.M.J. 1923, p. 7.
320. P.R.S.Q. 1924, p. 143.
321. P.R.S.Q. 1924, p. 139.
322. T.N.Z.I. 1924, p. 124.
323. P.R.S.Q. 1915, p. 105 *et seq.*
324. A.A.A.S. 1924.
325. Q.G.S.P. No. 223, p. 12.
326. Q.G.M.J. 1909, p. 185.
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DESCRIPTION OF FIGURES 1 TO 4.

FIG. 1.—Sketch Map of Queensland, showing the more important Pre-Cambrian and Lower Palæozoic Trends (continuous lines), the Middle Palæozoic Trends (broken lines), and the principal Serpentine Belts.

Some of the trends mapped as Middle Palæozoic, and more particularly the north-easterly trends, may, when further evidence is forthcoming, prove to be of Lower Palæozoic age.

FIG. 2.—Sketch Map of Queensland, showing the greatest of the many supposed trough faults formed at the close of the Palæozoic era, and the more important axes of the folding movement which closed the Mesozoic era.

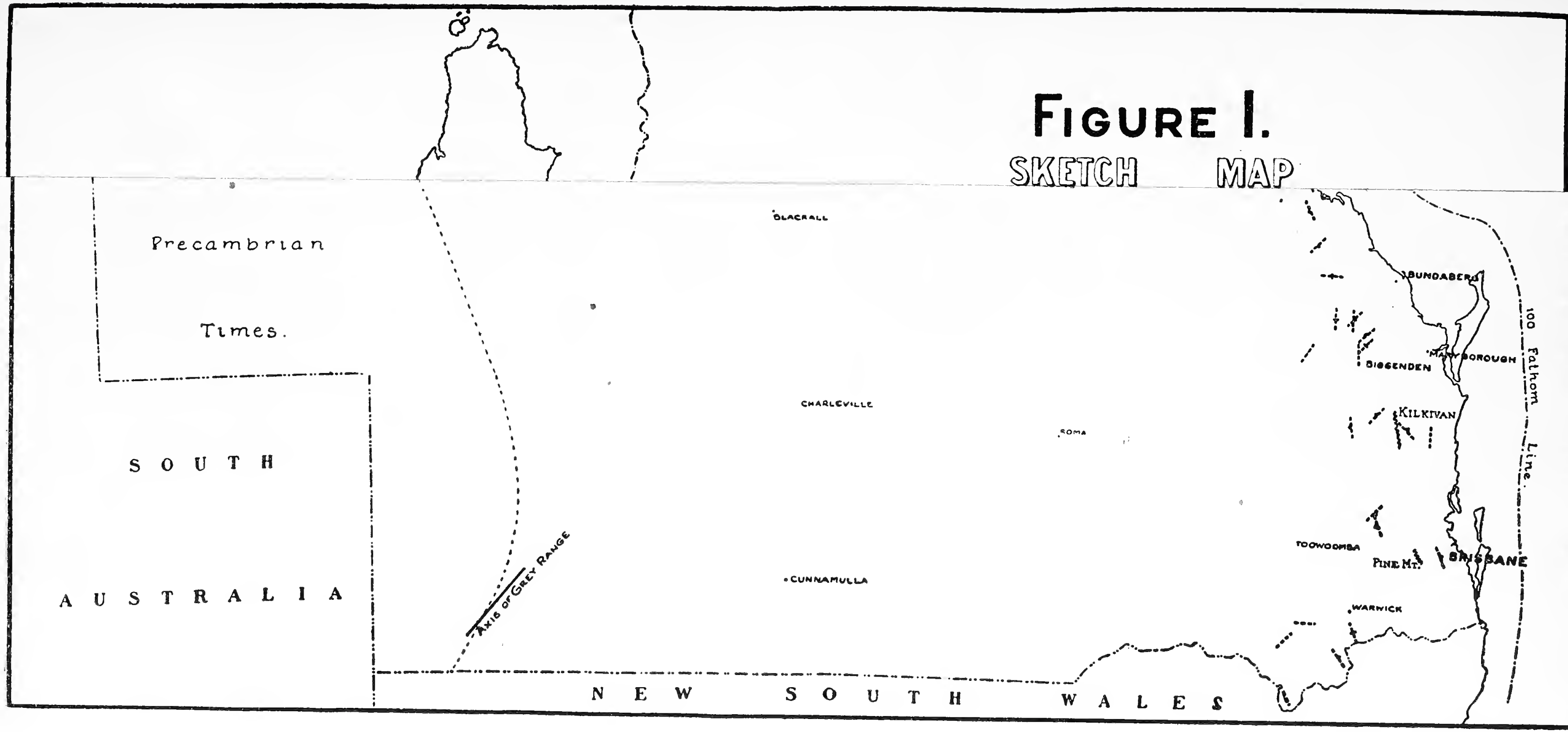
FIG. 3.—Diagrammatic Section from Injune to Fraser Island, showing partial restoration of the supposed Great East Queensland Geanticline and the position of the more important anticlinal axes. (The Springsure-Wallumbilla Anticline becomes much more marked as one proceeds north from the point where this section crosses it.)

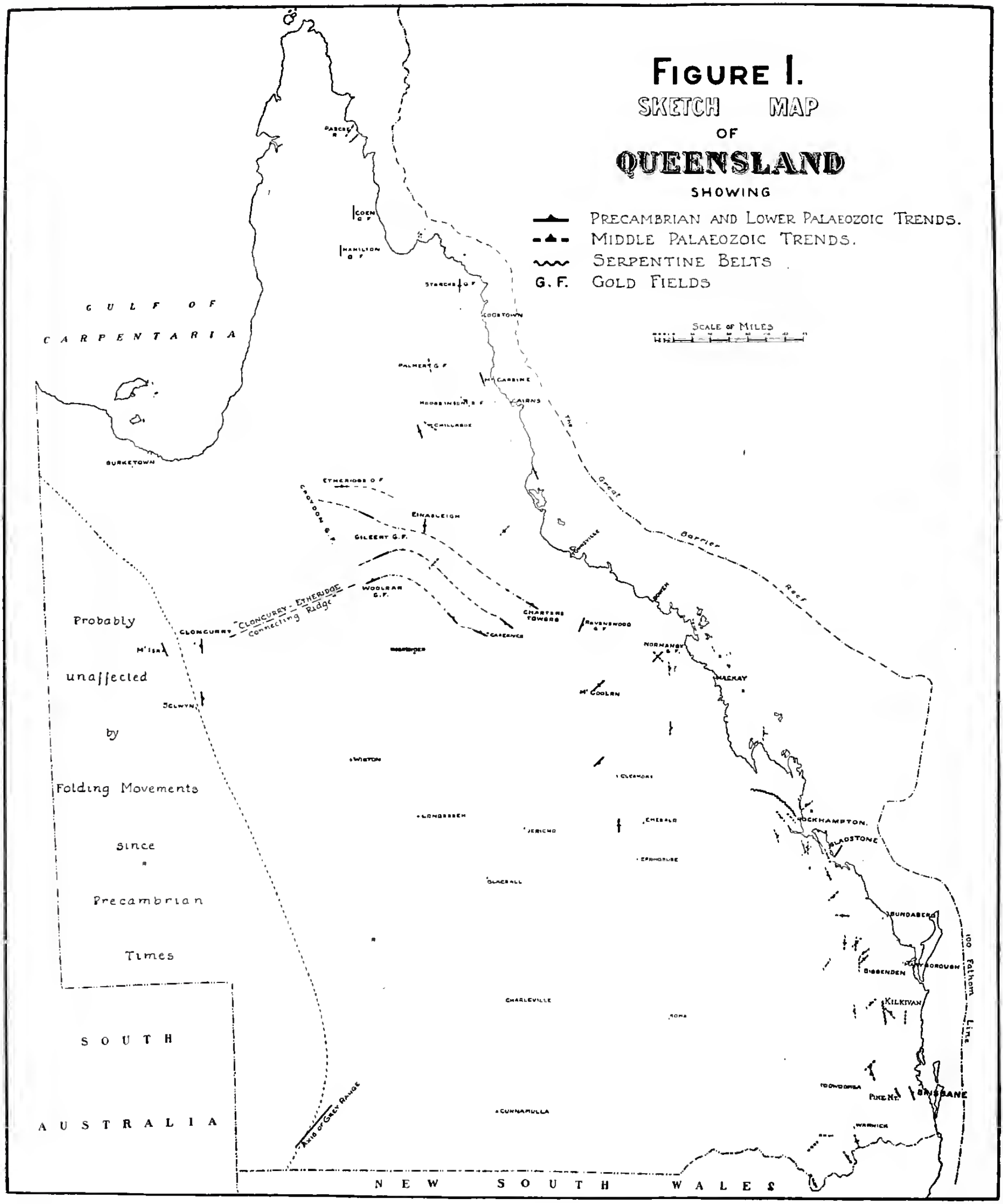
The conformability of the Upper Palæozoic with the Mesozoic formations, and the essential simplicity underlying the apparent complexity of the geological structure of Eastern Queensland, are suggested by this section.

FIG. 4.—Sketch Map of South-Eastern Queensland and North-Eastern New South Wales, showing how the suggested break in trend which is supposed to have closely followed the orogeny of the Kanimbla epoch appears to have resulted in the dislocation and lateral displacement of the Pre-Carboniferous formations and the arrangement *en echelon* of the Carboniferous Series.

FIGURE I.

SKETCH MAP





PROC. ROY. SOC. Q'LAND, VOL. XXXVII.

FIGURE 2.

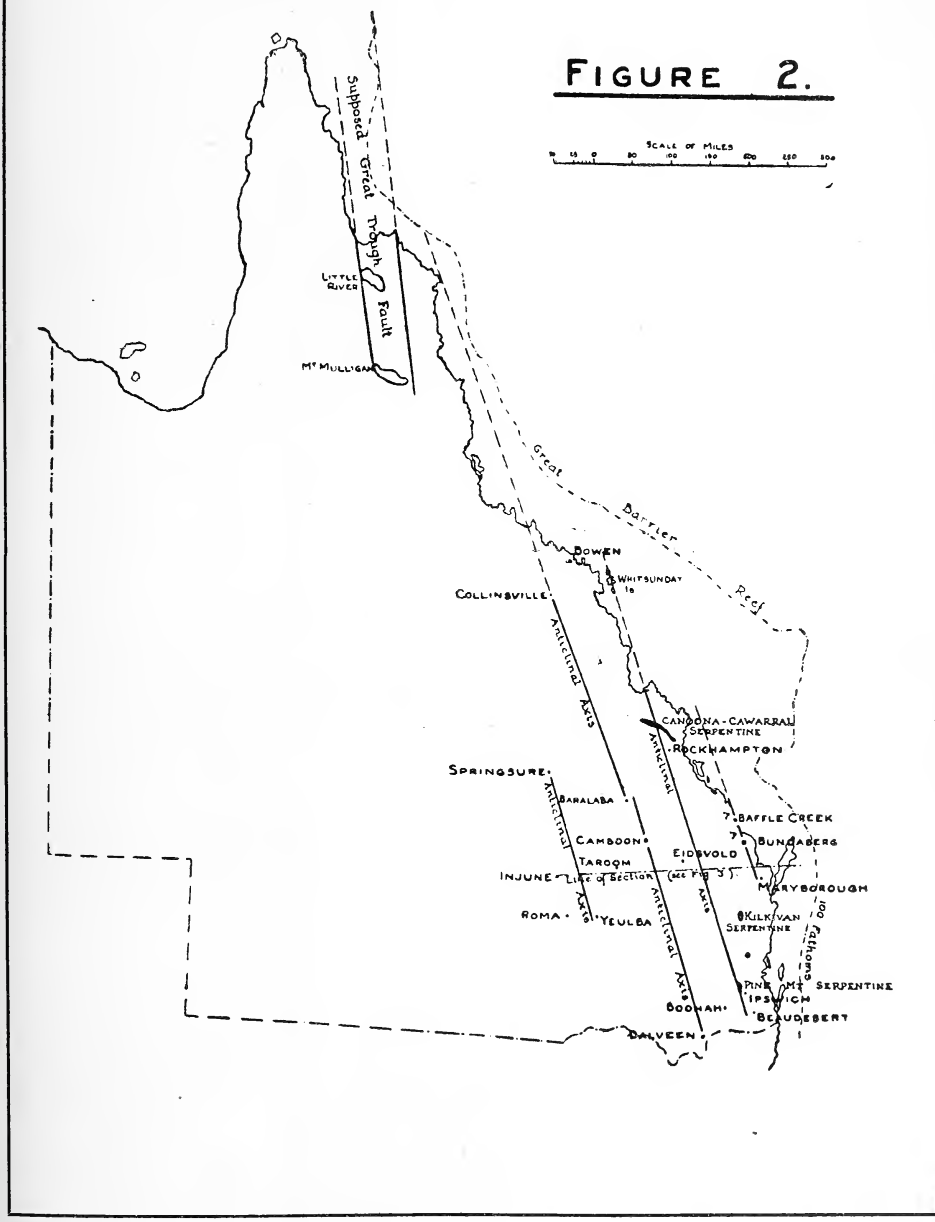
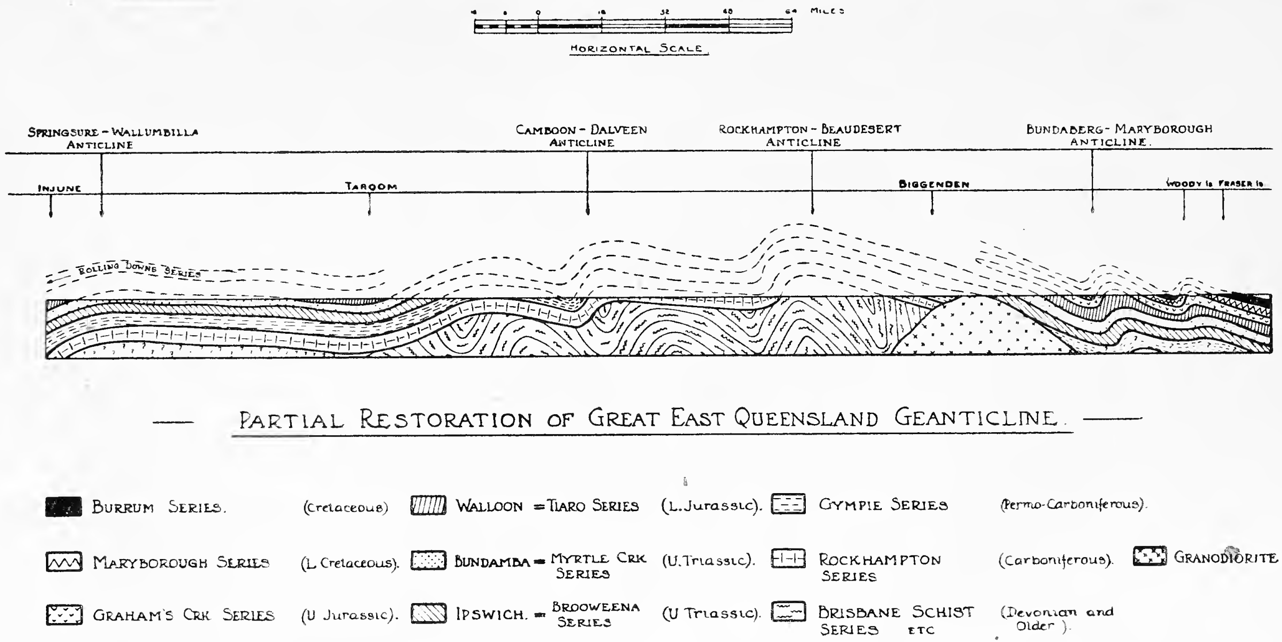

Scale of Miles
Supposed Great Trough Fault
Little River
Mt Mulligan
Great Barrier Reef
Bowen
Whitsunday Is
Collinsville
Anticlinal Axis
Canoona - Cawarral Serpentine
Rockhampton
Anticlinal Axis
Springsure
Baralaba
Anticlinal Axis
Camboon
Taroom
Injune
Line of Section (see Fig 3)
Eidsvold
Baffle Creek
Bundaberg
Maryborough
Roma
Yeulba
Anticlinal Axis
Axis
Kilkivan Serpentine
100 Fathoms
Pine Mt Serpentine
Ipswich
Boonah
Beaudesert
Dalveen

FIGURE 3.

DIAGRAMMATIC SECTION FROM INJUNE TO FRASER ISLAND.



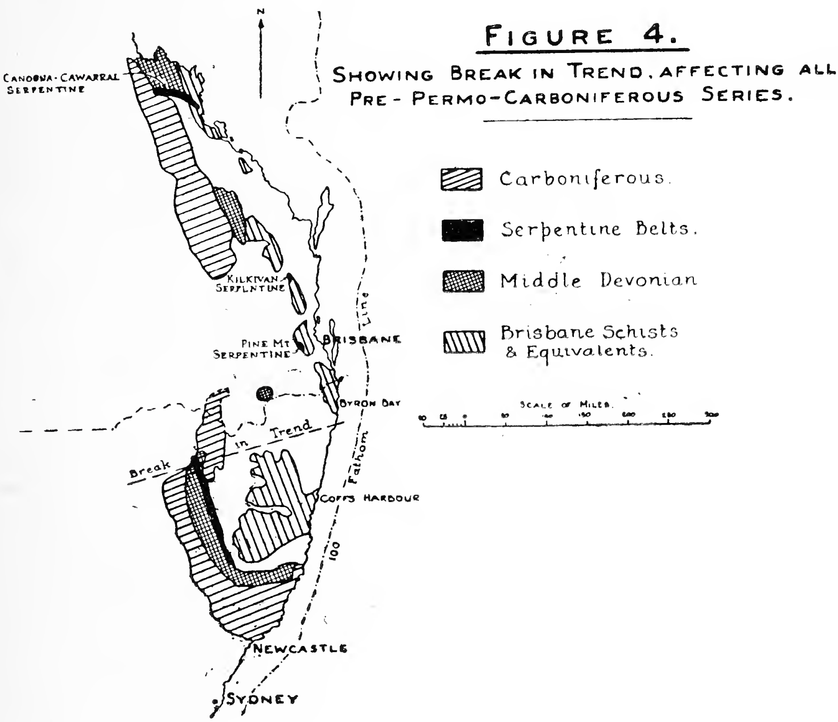


FIGURE 4.

SHOWING BREAK IN TREND, AFFECTING ALL PRE-PERMO-CARBONIFEROUS SERIES.

The Granites of Croydon and the Supposed Intrusive Bar.

By H. I. Jensen, D.Sc.

(*Read before the Royal Society of Queensland, 27th April, 1925.*)

In his report on the Croydon Goldfield in 1896 and other Croydon reports, Mr. W. H. Rands enunciated two theories which have been the cause of much scientific controversy, and have led to much expenditure of money and energy in the endeavour to pick up "lost reefs" on the Croydon field. Firstly, he maintained that the main granites of the field were metamorphosed sediments, a contention which he also applied to the Etheridge field and which, in regard to the Etheridge, was very stoutly resisted by Walter Cameron and other geologists. Rands also held that there was an intrusive bar intersecting the "metamorphic" granites of Croydon, and that it was due to this intrusive bar the gold in the rich Lady Mary and Iguana reefs came to a dead-end. Rands defined this intrusive bar, and the acceptance of his theories led to a search for the "lost reefs" on the opposite side of the supposed "intrusive bar."

Mr. Dunstan, in his reports of 1906 and 1907, seems to have accepted the intrusive bar and metamorphic granite hypotheses. In 1919 I visited Croydon on several occasions and went into the question. My conclusion was emphatically that there was no metamorphosed granite formed from sediments, that the graphitic reefs were not metamorphosed coal seams, and that all the granites of the field belong to the same igneous series, although some differentiates of the magma are dyke-like later injections. I could find no evidence of any later intrusive bar. The break in the Iguana and Lady Mary reefs I concluded to be a fault, and the reefs east of the fault, like the Waratah-Black Snake reefs, are the upthrown equivalents of reefs that would be met with by boring through the shallow sandstone capping in the Racecourse and Hospital Reserve west of the Iguana-Lady Mary reefs.

In 1919 I examined a number of sections of granites from Croydon, representative both of the supposed intrusive bar and of the supposed metamorphic granite. I found that all these granites were alike in mineral composition and degree of metamorphism. Slight differences exist in the relative proportions of constituents, as is usual in specimens from various parts of the one rock-mass, and slight differences exist also in degree of decomposition, which was also to be expected, as some were surface specimens and others from mines. The petrological examination confirmed my opinion that Rands' "intrusive bar" is non-existent, and that all these granites are primarily igneous and belong to the one great intrusion. There has been a certain amount of metamorphism subsequent to intrusion showing as kaolinisation, sericitisation, and chloritisation. This metamorphism has been caused by a subsidence of the consolidated granites into a deeper zone of the earth's crust than that in which they consolidated. The granite mass is probably very early Palæozoic, though probably newer than the felsites. The identity of the granite of the "intrusive bar" and that of Cole's bore having been established, the speculative nature of sinking the Iguana Consols shaft became so much the clearer. This petrological examination also strengthened the recommendations for boring made by me in an official report.

No. 1: Gneissic granite from Croydon King, 6 miles from Croydon, typical of that locality. Hand specimen dark-coloured, coarse-grained, and somewhat laminated, the quartz being gathered in streaks. This granite type is called "metamorphic" in Rands' reports.

Microscopically the rock is holocrystalline, uneven-grained, and hypidiomorphic-granular to graphic in structure. The minerals are, in order of decreasing amount, quartz, felspar (mostly decomposed), chloritised hornblende, and magnetite. The quartzites and felspars are hypidiomorphic, and in many parts of the slide certain felspar crystals are surrounded by a secondary growth of quartz and felspar, forming a graphic myrmekite mixture, that is arranged alternately in a peglike manner around the original crystal. These graphic growths are principally round orthoclase decomposing to kaolin. Oligoclase felspar is equally abundant and is strongly sericitised. The hornblende has completely decomposed to chlorite pseudomorphs. The rock shows strong evidence of recrystallisation and alteration under the influence of regional metamorphism, but there is nothing to imply formation from sediments.

No. 2: Granite from "Flaherty's Show," Stanhills, 10 miles from Croydon. Hand specimen coarse-grained, dark-coloured, and even-grained. It is supposed to be an igneous (plutonic) type.

Microscopical Examination.—Holocrystalline, even-grained, allotriomorphic granular structure. The rock consists of quartz, felspar, and hornblende. The felspar is mostly a highly altered plagioclase which by regional metamorphism has been changed into a mosaic of sericite, diopside, albite, and quartz. The oligoclase is less decomposed than the more basic felspar. Sphene apatite and magnetite are present as minor constituents. The hornblende is a common green hornblende, which in parts of the slide is more decomposed than in others, with formation of chlorite. This slide too indicates the regional metamorphism of a pre-existing granite.

No. 8: Granite from Hope Tin Mine, 10 miles from Croydon. This has the appearance of a true plutonic granite. It is slightly lighter in shade than 1 and 2.

Microscopic Examination.—The same minerals are present as in No. 1 and No. 2 and in the same order. The texture is between those of No. 1 and No. 2, inasmuch as graphic myrmekite intergrowth of quartz and felspar appears in several places. The felspars, originally oligoclase and andesine, show great alteration to sericite and quartz. The hornblendes are more strongly resorbed than in No. 2, and partly altered to uralite, partly to chlorite, but the original hornblende was a common hornblende. Metamorphism has given rise to a little garnet and topaz.

This slide, like Nos. 1 and 2, shows no evidence of the rock being derived from sediments. The felspar and quartz phenocrysts are subangular and shaped as one sees them in igneous rocks. If the parent rock had been a sediment, one would expect to see traces of an original rounded core of quartz and felspar surrounded by a secondary growth of more recent quartz or felspar. These rocks show some recrystallisation of ground-mass and mineral rearrangement, but the grain shape points to igneous origin. The hornblende is typical igneous hornblende. The fibrous actinolite or the bladed hornblendes of metamorphic rocks are characteristically absent.

No. 12: This was a red decomposed granitic rock taken on Iguana Hill, town of Croydon, west of the lode outcrop, and looked like a stone which might with reason be termed "metamorphic granite." Nevertheless, under the microscope it proved to be quite similar to 1, 2, and 8, excepting in that it was more decomposed through proximity to the lode channel. Graphic structure was observed in places as in Nos. 1 and 8. The felspars were completely sericitised and kaolinised. The hornblende was reduced to skeletons of red iron oxide, even chlorite having quite vanished, yet texture and composition showed it to be a rock similar to 1 and 8, and to have no semblance of sedimentary origin. Decomposition was due to pneumatolysis.

No. 32: This was a reddish decomposed rock occurring on the footwall side of the reef in Nos. 9 and 10, North Golden Gate. In hand specimen it had the appearance of a pegmatitic granite. This appearance was confirmed by microscopic examination, which makes it a hypidiomorphic granular even-grained aplite. The felspars consist of an earlier orthoclase which is somewhat kaolinised and a later plagioclase which is strongly sericitised. Alteration products after hornblende are absent but occasional magnetites are present.

This rock is a dyke offshoot of the main footwall granite, and its occurrence here points strongly to the possibility of an untouched true footwall reef existing in this locality below the lode, as was hoped by Hansen and party, who were at the time sinking for it.

No. 10: Supposed metamorphic granite. True Blue, 3 miles N.N.W. of Croydon. In hand specimen this was aplitic looking. Microscopically the rock proved an oligoclase-orthoclase quartz rock of the aplite family, strongly kaolinised and sericitised. Magnetite skeletons show that a trace of hornblende was originally present. There is no trace of sedimentary origin.

In the case of the following seven rocks, Rands' interpretation was widely accepted by the mining people of Croydon.

No. 3: Granite, "intrusive bar" (Rands), Croydon. Typical granite texture. Allotrimorphic granular, holocrystalline and coarse-grained composition; quartz and felspar (more or less decomposed) are the principal minerals, and have a slight tendency to hypidiomorphism; hornblende is less abundant, very corroded, yet showing the relict of idiomorphic habit, and the mineral is almost completely altered to chlorite and sericitic mica. The felspar consisted originally of an oligoclase micropertlhite. It has been kaolinised and sericitised. No primary magnetite shows in the slide though it is probably sparingly present in the rock. It is unquestionably a true igneous rock.

No. 4: Supposed "metamorphic" granite, core from Cole's Bore. Texture and mineral composition absolutely similar to No. 3, so much so that if the granite of the "intrusive bar" is a newer intrusion this rock must be classed the same, or if this rock is classed as metamorphic the intrusive bar is non-existent. The hornblendes in this slide are less altered to chlorite than in No. 3, and in one or two cases metamorphism has caused augite granules to form in the decayed hornblende. No primary magnetite was seen in the slide, but a little is probably sporadically present in the rock. A little dusty secondary magnetite seems to be present, though this may be carbon.

No. 5: Granite. Iguana Consols shaft, supposed metamorphic. In texture and mineral composition this rock is the same as 3 and 4, though the felspar content is higher in lime felspar showing sericitic-calcitic decomposition than the previous. However, the microperthitic oligoclase is very pronounced. The hornblendes are hypidiomorphic light-green grains, studded as usual with magnetite-ferrite alteration products, and in some crystals passing strongly into chlorite. A few small crystals of primary magnetite are present. The rock has no features that would justify one in regarding it as a metamorphosed sediment.

No. 6: Granite out of face of intrusive bar in the Ophir Shaft. This rock is in texture similar to the three above. The composition is also similar though the felspar is partly orthoclasic, partly oligoclasic, microperthitic, and decomposing mainly to kaolin. Strong decomposition to sericite was noticed in a large crystal studded with inclusions and having the appearance of enstatite. Similar masses, but smaller, were present in some of the previously described slides but were taken for basic felspar decomposed. Near the enstatite mass is a small crystal of augite, probably secondary. Primary hornblende (green pargasite) decomposing slightly to chlorite and ferrite is scattered about in corroded crystals. There is no magnetite showing in the slide.

No. 7: Granite from "footwall" country. Tracey's Shaft, Golden Gate. Supposed intrusive. This rock was, under the microscope, remarkably like No. 6. Orthoclase predominates among the felspars, hence kaolin is the main felspar decomposition product. The hornblende is corroded pargasite, and was as usual an early product of consolidation. A little original magnetite is present, both as inclusions in hornblende and outside it. The sericitic pseudomorphs after enstatite are occasionally present. The rock is certainly igneous.

No. 11: Granite from "footwall" country. Nos. 9 and 10, North Golden Gate. This granite is like Nos. 6 and 7 in texture and composition. The felspar is principally kaolinised orthoclase. The hornblende less altered than usual, being in the main quite fresh, though as usual corroded. A little secondary augite has developed in the hornblende, unless indeed it was primarily included. Apatite is present in small amount, but very little magnetite was seen in the slide.

No. 25: Granite from True Blue end of Rands' intrusive bar. Rock coarse-grained, hypidiomorphic, granular, and even-grained. The minerals are the same as in the previous—viz., quartz, felspar, green hornblende, sericitic aggregates possibly after enstatite, apatite, and magnetite, with chlorite and kaolin as decomposition products. The felspar is partly orthoclasic, partly oligoclasic, as in 6, 7, 11. The hornblende is mostly fresh, though some crystals show alteration to magnetite and chlorite. Magnetite is only sparingly represented.

The whole of the rocks examined seem to be derivatives of the same magma, a hornblende granite low in iron, with medium silica percentage, and slightly higher in magnesia and lime than usual in some areas of the mass. Hence, plagioclase (andesine-labradorite) and possibly enstatite developed in parts. The hornblende is consistently the same variety throughout and typically the igneous species. In metamorphosed schists we would expect fibrous and lamellar species (actinolite, anthophyllite, etc.). All the rocks show evidence of metamorphism subsequent to consolidation, but submergence into Grubemann's "middle zone" of the earth's crust, where sericitation and chloritisation took place, and in the vicinity of shear zones where pneumatolytic action was rife, some recrystallisation simultaneously giving graphic structure (myrmekite), garnet, and topaz as alteration results.

There is nowhere any evidence of original clastic grains which by secondary growth have assumed granitic habit.

If these rocks were originally formed from sediments, those strata must have been so deeply sunk into the bowels of the earth as to have become completely fused, and would then virtually have become an igneous magma. The occurrence of the regularly dipping, consistently bedded graphite beds, which at first sight would seem to bear evidence in favour of coal-measure derivation, are really the strongest argument in favour of igneous origin; for sedimentary coal-beds enveloped in a fused mass would interact with the metallic oxides and be completely converted into carbon dioxide—thus, $2Fe_2O_3+3C=3CO_2+4Fe$. The abundance of quartz shows that the rock contains excess of silica. The iron would enter into the enstatite and hornblende molecules. Moreover, in a plastic and semi-flowing mass the coal-beds would be completely broken up. Further, there is no stratigraphical evidence of different bands of granite or granitoid rocks of different composition.

The sedimentary hypothesis can be entirely discarded. The graphite beds are due to some decomposition of carbon dioxide in shear zones with iron carbonyl formed as an intermediate product, and the petrological examination suggests that the source of the gold or the pneumatolysis which segregated the gold was some deeply buried intrusion or differentiate, probably dioritic, which is a much later phenomenon than the granite. That, however, is not proved.

The following note is "à propos":—"It is interesting to notice here that, according to Lacroix, myrmekite results from the replacement of the potash of the microline by soda and lime; and further, that according to Holinquist the presence of myrmekitic intergrowths is an evidence of great age and severe metamorphism in a granite." (Farquharson, Bull. 49, G.S., W.A., p. 59.)

Conclusion.—My contention is that the granites of Croydon are true igneous rocks which have been lowered into the zone of partial recrystallisation at some period in their history. They are very old Pre-Cambrian granites, as is the case with the granites of the Cloncurry massif.

During their period of re-elevation from the deeper zones of the earth's crust, strong thrust movements from the east and north-east caused a number of flat shear zones to form, in which pneumatolytic vapours deposited metallic minerals and graphite, also at the same time metasomatising the well-rocks in the vicinity of the shear zones, so that in the zone of weathering these changed granites are rather softer than the unchanged granite.

Faulting and faulting alone is the cause of the loss of certain rich reefs on the Croydon field, and to pick up new reefs one must sink west of the fault in the sandstone country, or otherwise follow down the fault along the wall known as the "intrusive bar" on the western side until the next reef in depth is met with.

The Essential Oils of Australian Menthas.

I.—*Mentha satureiodes.*

By T. G. H. Jones, B.Sc., and F. Berry-Smith, B.Sc., F.I.C.

(*Read before the Royal Society of Queensland, 27th April, 1925.*)

Notwithstanding the cultivation and commercial exploitation elsewhere of the genus, the Australian menthas have hitherto received little attention. A yield of about 0·8 per cent., recorded by J. F. Bailey (Queens. Flor., pt. 4, p. 1193), is, indeed, the sole notice in literature of the essential oil of *M. satureiodes,* Brisbane Pennyroyal, which may spring up abundantly after rain on parts of the Southern Queensland tablelands, and is, in addition, occurrent in all the Australian States except Tasmania.

M. satureiodes is a small perennial herb usually under 1 ft. in height. The leaves are sessile, generally oblong or oblong-lanceolate, but varying much in size and shape. The flowers are usually in whorls of six from the leaf axials, and are white in colour.

The authors, by steam distillation of wilted plants received from the Dalby district in December, have obtained a yield of 0·2 per cent. only of essential oil, considerably lower than that recorded by Bailey. It may be observed, however, in regard to menthas of Europe and America that yield is much influenced by soil, season, and time of harvesting. The essential oil obtained has proved sufficient for determination of the main constituents.

The essential oil of *M. satureiodes* resembles the pennyroyal oils of commerce in containing as principal constituent the ketone pulegone (40 per cent.) which is characteristic of these, comprising up to 80 per cent. of European oil (*M. pulegium*) and 30 per cent. of American oil of pennyroyal (*Hedeoma pulegoides*). Other constituents of the oil are 1-menthone, 1-menthol, and menthyl acetate, and a small percentage of lower boiling bodies from which no definite constituent could be isolated, but in which the presence of limonene was indicated.

Experimental.—One hundred pounds of partly dried plants yielded on steam distillation 93 grammes of essential oil, pale yellow in colour and possessing the agreeable odour of peppermint, for which the following constants were determined:—

$d_{15 \cdot 5}$ 9278 ; n_{D25} 1·469 ; $(\alpha)_D$ + 2·8
ester val. 23 ; acetyl val. 57.

In a trial experiment 10 ccs. of oil shaken for several hours with neutral sodium sulphite solution showed an absorption of 40 per cent. by volume.

Isolation of Pulegone.—The whole of the oil available (75 ccs.) was then shaken out with a solution of sodium sulphite until absorption appeared complete. There was obtained from the separated aqueous layer on rendering alkaline an oil which on purification possessed the following constants and was apparently homogeneous:—

B. pt. (32 mm.) 118-120°C.; (760 mm.) 224°C.; $d_{15\cdot 5}$ ·9399 n_{D20} 1·4888; $(\alpha)_D$ + 18·3. Found C = 78·6 per cent., H=10·4 per cent.

These values agree closely with those recorded for pulegone, and identity with this body was confirmed by preparation of a semi-carbazone melting at 171° C., and of the bisnitroso compound which melted at 83·5° C., or two degrees higher than the melting point given by Gildemeister and Hoffmann (The Volatile Oils, 2nd edition, vol. i., p. 447). The residual oil after extraction of pulegone possessed optical rotation α=—7 in 1 dcm. tube. Treated with alcoholic potash to hydrolyse esters it was then found to be dextro-rotatory (α = + 2·2 in 1 dcm.) in conformity with liberation of menthol from highly lævo-rotatory menthyl acetate and with partial conversion of 1-menthone to d-iso-menthone. In the aqueous liquor remaining from saponification by potash and recovery of the oil was found in appreciable amount only acetic acid.

Fractionation of Residual Oil.—The oil recovered from saponification was distilled under 30 mm. pressure and three fractions were collected, viz.:—

(*a*) Below 100°C.	4 ccs.	α (1 dcm.) =	+ 3
(*b*) 100–110°C.	24 ccs.	α	+ 4
(*c*) 110–120°C.	12 ccs.	α	— 2

The distillation range was mainly 107-115° C., a small amount only being collected above the latter temperature.

Identification of 1-Menthone.—Fractions (*b*) and (*c*) were separately treated with hydroxylamine hydrochloride and sodium bicarbonate, and the resultant oils extracted in turn with 5 per cent. and 20 per cent. sulphuric acid. Five per cent. acid removed from fraction (*c*) a little crystalline material, separating on neutralisation, soluble in ether and crystallising therefrom in long needles, which on recrystallisation from alcohol melted sharply at 157° C. The substance was thus shown to be "pulegone hydroxylamine" (Gildemeister and Hoffmann, vol. i., p. 446), derived from a small quantity of pulegone escaping extraction in the initial treatment with sodium sulphite. Neutralisation of 20 per cent. acid, in which both fractions had largely dissolved, separated in each case a lævo-rotatory oil (α= —6 in 1 dcm.), evidently an oxime. The ketone liberated therefrom by treatment with sulphuric acid possessed constants agreeing closely with those of menthone:—

B. pt. (760 mm.) 207-208°C; $(\alpha)_D$ + 8; $d_{15\cdot 5}$ ·8942; n_{D20} 1·450; Found C = 77·8. H = 11·6.

Rotation + 8 being the equilibrium value attained when l-menthone is regenerated from its oxime with sulphuric acid or when partially converted by alkali to dextro-rotatory iso-menthone, the occurrence in the oil of menthone in the l-form was to be inferred. In the preparation of a semi-carbazone there were separated needles which after repeated crystallisations melted at 184° C., the recorded melting point of l-menthone semi-carbazone, the more soluble semi-carbazone of d-iso-menthone being eliminated in the crystallisation (*cf.* Barrowcliff, J.C.S., Trans. 91, 883).

Isolation of Menthol.—The oil (8 ccs.) recovered from the separation of menthone oxime was lævo-rotatory and possessed strongly the odour of menthol. On heating with 10 grammes phthalic anhydride and 20 ccs. benzene during five hours there was yielded an acid phthalate melting after purification at 110° C., the recorded melting point of acid phthalate of menthol. The regenerated menthol readily solidified in a freezing mixture, and its identity was further established by preparation of the urethane melting at 111° C. after recrystallisation from alcohol.

The residue of oil (2 ccs.) recovered from the menthol extraction was found after distillation over sodium to boil at 180-190° C., and yielding a small amount of crystalline bromide, probably contained limonene. Fraction (*a*) after distillation from sodium amounted to 2 ccs. It was evidently largely terpenic in character, but beyond a semi-carbazone insufficient for identification no definite derivative could be obtained from it.

The constituents of the essential oil of *M. satureiodes* are associated in approximately the following proportions:—

Pulegone 40, l-menthone 20-30, l-menthol 12, menthyl acetate 8; lower boiling constituents (not determined) 5-10 per cent.

The authors' thanks are due to Mr. J. H. McCarthy, Stock Inspector, Dalby, for valuable assistance in obtaining the supply of material worked on, and to Mr. C. T. White, Government Botanist, for confirmation of identity of specimens submitted.

Elemi—The Oleo-resin of *Canarium Muelleri.*

By T. G. H. Jones, B.Sc., A.A.C.I., and F. Berry-Smith, B.Sc., F.I.C.

(*Read before the Royal Society of Queensland, 27th April, 1925.*)

The similarity to pharmaceutical elemi of the oleo-resin of *Canarium muelleri* (N.O. Burseraceæ), a lofty tree endemic in tropical Queensland and of exclusively Australian occurrence, is cited by F. M. Bailey (Comprehensive Catalogue of Queensland Plants).

The constituents of elemi resins of commerce have been investigated by Tschirch and collaborators (Arch. Phar. 1902, 240, 293-294; 1903, 241, 149-159); the composition of elemi oils by several investigators, notably that of *Canarium luzonicum* (Manila elemi) by Clover, and subsequently by Bacon (Phil. Journ. Sci. 2, 1907, A, i.; 4, 1909, A, 93).

According to Clover the dominant constituent in the essential oil of this species is either limonene or phellandrene, there being, as observed also by Bacon, a remarkable variation in the composition of individual oils of the species.

Tschirch and Cremer (*loc. cit.*) found as characteristic and sole alcoholic constituents of elemi resins examined by them crystalline isomeric α and β amyrin, $C_{30}H_{50}O$, and as minor constitutents, together with resene, crystalline and amorphous acids of either the elemic acid ($C_{37}H_{56}O_4$) or eleminic acid ($C_{39}H_{56}O_4$) group.

Vesterberg, however (Ber. 20, 1241-1246; 23, 3186-90; 24, 3836-43), to whom investigation of amyrin is principally due, found certain elemis to contain also non-crystalline alcohols.

Examination by the authors of three samples of oleo-resin derived from *Canarium muelleri* does not reveal any such variation in the constituents of the esential oil as recorded by Clover for Manila elemi oil.

The principal constituent of the oil was constantly 1-α-pinene; α-terpineol, dipentene, and 1-α-phellandrene also occurring. The high boiling constituent, oxygenated sesquiterpene, obtained by Clover was not present.

In contrast to the elemis described by Tschirch the resin of *Canarium muelleri* does not contain crystalline amyrin as a separable entity, but in amount constituting it the major constituent amorphous alcoholic material, possibly a mixture of closely related bodies, isomeric with amyrin and distinguished therefrom by lower optical rotation and wholly non-crystalline character of derivatives.

The identification of "amorphous amyrin" in the resin of *Canarium muelleri* is significant both in relation to Tschirch's suggested classification of true elemis as containing α and β amyrin or related alcohols, and to Vesterberg's indication of the presence of non-crystalline alcohols in certain Canarium resins.

The alcohol slowly combines with phthalic anhydride, being separable from resene by that means, and is oxidised by chromic acid to resinous aldehyde or ketone. Acetyl and benzoyl derivatives are amorphous, and sparingly soluble in alcohol.

Other constituents of the resin are isomeric crystalline and amorphous acids of molecular composition distinct from elemic and eleminic acids, and amorphous resene material possessing molecular composition approximating that required for $C_{15}H_{24}O$.

Experimental.—The oleo-resin of *Canarium muelleri* is a viscous mass, light amber in colour, possessing the odour of turpentine. On long exposure it becomes resinous, hard, and brittle; 1,909 grammes collected in 1922 distilled with steam yielded 550 grammes (28·8 per cent.) of essential oil; 1,916 grammes collected in 1924, distilled at 100 mm. and subsequently at 2 mm. pressure from an oil-bath heated at 200° C., yielded 636 grammes (33 per cent.) of essential oil. In the latter case, approximately 100 ccs. of water were collected with the oil, and in each case about 1,100 grammes of hard brittle resin remained in the still. The one other sample examined gave similar results.

The following constants were recorded:—

1922 sample (distilled in steam).	1924 sample (distilled in vacuo).
$d_{15 \cdot 5}$ ·868	$d_{15 \cdot 5}$ ·8716
N_{D20} 1·463	N_{D20} 1·4662
$[\alpha]_D$ — 16·2	$[\alpha]_D$ — 25·2
Acid and ester values, Nil	Acid value, 5
Acetyl value, 10·3.	Acetyl value, 28
	Ester value, 1·5.
Resin.	Resin.
Acid value, 9	Acid value, 2
Ester value, nil	Ester value, 13
Acetyl value, 78.	Acetyl value, 71.

The higher alcohol constant of the essential oil distilled from the oil-bath in vacuo (Clover, *loc. cit.*) is due to more efficient removal of the higher boiling constituent, and altered acid, ester, and acetyl values of the resin are no doubt attributable to the interaction of the resin alcohol and acid.

Examination of the Essential Oil.—The examination of the essential oil obtained from the oleo-resin by distillation in vacuo is alone described, the oil obtained by steam distillation differing materially only in alcohol content and somewhat lower optical rotation.

A slight odour of volatile fatty acid was perceptible, and extraction with dilute NaOH solution gave on isolation an acid which was identified as butyric or iso-butyric acid by means of its silver salt (Found Ag = 54·8 per cent.).

600 ccs. of oil were fractionated at 30 mm. pressure, and after several refractionations yielded ultimately—

(*a*) 350 ccs. boiling at 155-156° C. (760 mm.)
(*b*) 32 ccs. boiling at 160-170° C. (760 mm.)
(*c*) 33 ccs. boiling at 170-180° C. (760 mm.)
(*d*) 65 ccs. boiling at 110-118° C. (24 mm.)

Fraction (*a*) twice distilled over sodium possessed the following constants :—B.P. 155-156° $d_{15\cdot5}$ 0·8636 N $_{D20}$ 1·4651 $(\alpha)_D$ — 21·7°. (Found C = 87·7, H = 11·9.) Identity with 1α-pinene was confirmed by the preparation of a nitrosyl chloride melting at 107°C and of pinonic acid.

Oxidation with permanganate in the prescribed manner and search for nopinic acid failed to reveal the presence of β pinene.

Fraction (*b*) consisted largely of pinene; phellandrene and dipentene were also detected as in fraction (*c*) described below.

Fraction (*c*) redistilled from sodium gave the following results on analysis :—$d_{15\cdot5}$ ·8554 N $_{D20}$ 1·473 $(\alpha)_D$ — 33·6 (Found C = 87·8, H = 118)—and proved to be a mixture of terpenes.

Dipentene was identified by means of its tetra-bromide, prepared by addition of bromine to a solution of 5 ccs. of the fraction in ether amyl alcohol solution. An oily bromine separated which slowly solidified. On recrystallisation several times from alcohol it melted at 124° C., and failed to depress the melting point of an authentic specimen of dipentene tetra-bromide.

The presence of 1α-phellandrene was determined by the formation of phellandrene nitrosite melting at 115° after isolation and purification in the manner prescribed by Smith, Hurst, and Read (J.C.S. Trans. 1923, 123, 1657).

The presence of 1-limonene, β-pinene, and p-cymene could not be detected.

Fraction (*d*) possessed the characteristic odour of terpineol. By refractionation there was obtained a portion with the following constants :—

$d_{15\cdot5}$ ·9421, N $_{D20}$ 1·4773, $(\alpha)_D$ — 33·7 B.P. 115°C (20 mms.) 218°C (760 mms.). (Found C = 77·7, H=11·5).

Identity with α-terpineol was established by means of the nitrosyl chloride melting at 112° C. and by reaction with phenyl isocyanate, the resulting phenyl urethane after purification melting at 113° C.

The essential oil is composed of approximately 75-80 per cent. of 1α-pinene, 12 per cent. of α-terpineol (as determined from the acetyl value) with small amounts of 1α-phellandrene and dipentene.

Examination of the Resin.—The amber-coloured, brittle resin, which in contrast to the essential oil was dextro-rotatory, was readily soluble in chloroform, ether, turpentine, and petroleum ether, but incompletely soluble in alcohol.

Isolation of a Resin Acid $C_{28}H_{45}O_2$.—In order to isolate resin acids, the resin, in lots of 100 grs. for each experiment, was boiled under reflux with alcoholic sodium hydroxide solution in order to decompose resin esters, the alcoholic solution evaporated, and the residue extracted with petroleum ether. Sodium salts of resin acids obtained as a residue were collected, thoroughly washed with petroleum ether, and decomposed with dilute sulphuric acid, the liberated acid being taken up with ether. On evaporation of the solvent a resinous mass remained which, after solution in ether petroleum mixture, slowly crystallised as the solvent evaporated. After repeated crystallisation the acid was obtained as needles melting at 215° C. Found C = 80·7 H = 10·8 Acid No. 133 $(\alpha)_D$ in chloroform + 43. Calculated from these results the formula of the acid which is monobasic is $C_{28}H_{45}O_2$. (Required C = 81·3, H = 10·9).

The mother liquors after removal of the crystalline acid could not be induced to crystallise further, and by isolation by means of a silver salt there was obtained therefrom a small amount of amorphous acid material. Found C = 80·8, H = 10·8 Acid No. 132, $(\alpha)_D$ in chloroform + 48·0. Melting point 82-84° C.

The alkali salts of both acids were insoluble in water and amorphous, but soluble in alcohol. (Found Na = 5·4.) The amorphous silver salts tended to rapidly gelatinise. Found Ag = 20·5, 20·4 ($C_{28}H_{44}O_2Na$ reqs. Na = 5·2; $C_{28}H_{44}O_2Ag$ reqs. Ag = 20·8).

These figures indicate that the amorphous acid is isomeric with the crystalline, and that neither acid conforms to the formulæ ascribed by Tschirch to elemic and eleminic acids, although it is to be noted that the melting point of the crystalline acid is identical with the melting point recorded for these.

Separation of Resin Alcohol, "Amorphous Amyrin."—The resin after removal of the acids possessed an acetyl value of 90, and gave in chloroform $(\alpha)_D$ + 60·8. As all attempts to isolate crystalline alcohols in the manner prescribed for the separation of amyrin, and from various mixtures of solvents, were unsuccessful, 100 grammes of material were heated in an oil-bath under reflux with 75 grammes of phthalic anhydride and 50 ccs. of dry benzene for eight hours. On treatment of the melt with excess aqueous sodium hydroxide an insoluble sodium salt separated, apparently readily hydrolysed. Addition of concentrated brine facilitated separation. In all, three treatments with phthalic anhydride were necessary to completely remove all alcohol, as shown by absence of acetyl value in the residual resene. Purification of the acid phthalate was accomplished by repeated precipitation as sodium salt from ethereal solution. The silver salt was readily prepared. Found Ag = 16·0 ($C_{30}H_{49}O—C_8H_4O_3Ag$ reqs. Ag = 15·9).

The acid phthalate was hydrolysed by alcoholic sodium hydroxide, and the resin alcohol separated by solution in ether. Evaporation of the solvent left a brittle, resinous mass which could not be induced to crystallise. Fifty grammes of alcohol (melting indefinitely between 75° and 80° C.) were obtained in this manner from each 100 grammes of material treated, loss being difficult to avoid. Found C = 84·4, H = 11·6, $(\alpha)_D$ in chloroform + 50·7. ($C_{30}H_{50}O$ reqs. C = 84·5, H = 11·7 ; α-amyrin $(\alpha)_D$ + 91·2 ; β-amyrin $(\alpha)_D$ + 99).

The acetyl derivative was likewise amorphous. $(\alpha)_D$ in chloroform + 33·6 ester value, 118. Found C = 81·2, H = 10·8. ($C_{30}H_{49}O$. C_2H_3O reqs. C = 82·0, H = 11·1 ; ester value 120 ; (α amyrin acetate $(\alpha)_D$ + 77 ; β amyrin acetate $(\alpha)_D$ + 78).

In order to determine the homogeneity or otherwise of the alcoholic material, recourse was had to a method suggested by the recorded difference in solubilities of the esters of α and β amyrin (Vesterberg, Tschirch). Forty grammes of the finely powdered acetyl derivative were fractioned by successive treatments with boiling alcohol (300 ccs.), the solution being removed at room temperature, and five fractions were thereby obtained. The amounts, ester values, and specific rotations of the fractions are recorded in the subjoined table:—

Fract.	Grms.	e.v.	$(\alpha)_D$
1	7·3	119	+ 33·4
2	7·0	118	+ 33·5
3	6·9	119	+ 33·6
4	7·3	120	+ 33·6
Res.	9·0	118	+ 33·6

Similar results were afforded by parallel fractionation of the amorphous benzoyl derivative.

The figures may be interpreted as affirming at least preponderance of one alcoholic body, although the assumption of considerable admixture of isomers closely similar in properties is by no means negatived.

Oxidation of the Resin Alcohol.—Five grammes of alcohol were heated with 5 grammes chromic acid in acetic acid until reduction of the chromic acid was complete. On pouring the product into water a resinous mass separated, which in subsequent treatment showed no sign of crystallisation. Its aldehyde or ketonic property was demonstrated by reaction with hydroxylamine.

Attempts to remove a molecule of water from the alcohol by interaction with phosphorus pentachloride and with phosphorus pentoxide with production of hydrocarbon were not successful. Vigorous reaction occurred with charring, but nothing definite could be separated from the reaction product.

"Amorphous amyrin" yields with concentrated sulphuric and acetic acids the purple red colour reaction described as characteristic of crystalline amyrin.

The Resene.—The residual resinous material after separation of the alcohol was dark in colour, and powdered with difficulty. Aldehydic or ketonic properties could not be demonstrated in it, and both ester and acetyl values were nil $(\alpha)_D + 88{\cdot}6$. Found C = 81·5, H = 10·7 ($C_{13}H_{24}O$ reqs. C = 81·8, H = 10·9). Evidently resene, the material constituted about 30 per cent. of the resin, and was not further examined.

Summary.—The oleo-resin of *Canarium muelleri* has been found to contain:—

(1) 30 per cent. of essential oil consisting principally of 1-α-pinene with α-terpineol, dipentene, 1-α-phellendrene, and a trace of butyric acid.

(2) A residual resin consisting of—

(*a*) Acid material (7 per cent.), comprising crystalline and amorphous isomers ($C_{28}H_{45}O_2$) differing from elemic and eleminic acids of elemi resins previously described.

(*b*) Amorphous alcoholic material (60 per cent.), conforming to the formula $C_{30}H_{50}O$, possibly a mixture, isomeric with the crystalline amyrin occurring generally in elemis.

(*c*) Resene material (30 per cent.) of composition approximating to the molecular formula $C_{15}H_{24}O$.

We are indebted to Mr. E. H. F. Swain, Director of Forests, Brisbane, for supply of material utilised in the above investigation, and to Mr. C. T. White, Government Botanist, for verification of the authenticity of specimens.

A Contribution to the Theory of the Relationship of Iron to the Origin of Life.

By W. D. FRANCIS, Assistant Government Botanist.

(*Read before the Royal Society of Queensland, 29th June, 1925.*)

CONTENTS.

I.—INTRODUCTORY REMARKS.

The association of a botanist's name with a paper of this character requires some explanation. It is appropriate to indicate that the subject is connected with the study of Botany more intimately, perhaps, than is generally realised. For this purpose and because of its brevity the opening sentence of the second volume of Haas and Hill's work[1] on the chemistry of plant products can be quoted:—"The study of plant life, which in its fundamentals is physico-chemical, is in its broad aspect the study of the origin of life, since the plant arrived before the animal had its being."

The writer first became interested in the subject in 1915, when he incidentally observed certain physical properties of iron rust which led to the recognition of a correspondence in the initial stages of nutrition and respiration in plants and certain iron-depositing bacteria on the one hand, and the chemical processes involved in the rusting of iron on the other hand. At that time it appeared to the writer that the subject of the relationship of iron to the origin of life was one of unrealised possibilities. In 1919, upon return from service in Europe with the Australian Imperial Force, the study of the subject was resumed and a search was made in the various physiological and chemical journals and text-books available in Brisbane for references concerning iron in relationship to the functions of organisms. The search, which extended over a considerable period, yielded some interesting and surprising results. In addition to other records, it was found that Moore and Webster[2] in 1914 had advanced the theory that life arose in colloidal solutions or suspensions of salts or oxides of iron in the presence of carbon dioxide and under the action of sunlight. It is therefore apparent that the publication of this theory preceded the writer's conceptions on the subject, although the evidence submitted by Moore and Webster is of a different character from that advanced in this paper. Another author, N. Sacharoff,[3] has published a monograph in which iron is claimed to perform the leading part in organic functions. However, the correlation of several inorganic properties of iron or its compounds with certain organic functions also suggests the possibility of the relationship of iron to the origin of life. This appears to have escaped observation, and it is the object of this paper to place this aspect of the subject on record.

II.—A Summary of Previous Literature, which shows the Significance of Iron in Organic Functions.

The theory of Moore and Webster[2] assumes that life originated in colloidal solutions or suspensions of salts or oxides of iron, and is based upon the experimental synthesis of formaldehyde in colloidal solutions of ferric hydroxide in the presence of dissolved carbon dioxide and with the energy supply of sunlight.

In 1901 N. Sacharoff[3] published a monograph which has been translated into German and which bears the significant title "Das Eisen als das thätige Prinzip der Enzyme und der lebendigen Substanz." By means of experiments with papain in dissolving gelatine and analyses of papain, trypsin, pepsin, emulsin, diastase, and plant juices he concluded that the fundamental vital process is based upon the splitting of molecules of the living substance, whose cleavage is initiated by the oxidation of minute quantities of ferrous iron contained in them. The efficacy of the enzymes, he considers, is primarily due to the oxidation and reduction of similar small amounts of iron compounds contained in them. According to him, iron can be justifiably designated as the "enzyme of all enzymes." The iron is united with nuclein in a combination which he calls "bionuclein," which is a constituent of the living substance as well as of the enzymes, and, therefore, these two classes of materials are in close relationship.

As the result of an extended series of careful microchemical tests upon the cells of higher and lower forms of plants and animals, A. B. Macallum[4] concluded that one of the most marked charactertistics of chromatin is the occurrence in it of organically combined iron and nuclein or nucleic acid. The chromatin, in which iron is firmly held, he found to be a constant constituent of the nucleus of animal and vegetable cells, of the cytoplasm of non-nucleated organisms and those possessed of apparently rudimentary nuclei, and that further a similar iron-containing substance obtains in the cytoplasm of ferment-forming cells. On account of the primary importance of chromatin to the functions of the cell, it is pointed out by him that the cessation of the supply of iron to vegetable organisms affects not only the formation of chlorophyll, but strikes at the very life of the organisms. He further states that if the prevalent assumption attributing the oxygen-carrying capacity of hæmoglobin and of hæmatin to the iron contained in these compounds is correct, "it follows that the antecedent of hæmoglobin, chromatin, has the capacity of absorbing and retaining oxygen, and that one may attribute the processes grouped under the term 'vital' to an alternation of the conditions of oxidation and reduction in the iron-holding nuclear constituent.''

There is evidently a close correspondence in some of the conclusions of Sacharoff and Macallum. The ''bionuclein'' of Sacharoff is closely similar in chemical composition and physiological functions to the iron-containing chromatin demonstrated by Macallum. These authors attribute fundamental ''vital'' properties to bionuclein and chromatin respectively, and in each case these properties are assigned to the capabilities of oxidation and reduction of the contained iron compounds. Macallum's microchemical studies of ferment-forming cells also support in a remarkable way Sacharoff's conception of the composition of enzymes as substances containing iron compounds similar to those of nuclei, as Macallum found an iron-holding substance similar in composition to nuclear chromatin in the cytoplasm of ferment-forming cells. In the case of pancreatic cells Macallum[5] concluded that the chromatin of the nuclei passed into the cytoplasm of the cells and united with a constituent of the protoplasm to form zymogen which is the parent substance of the enzyme secreted by these cells.

W. D. Halliburton[6] calls the oxygen linked to hæmoglobin, the oxygen carrier of the blood, ''the respiratory oxygen of hæmoglobin,'' and states that the relation between the respiratory oxygen and the iron of hæmoglobin is quite constant, each gram of the iron uniting with 400 ccs. of oxygen or in the relation of one atom of iron to two of oxygen. As the result of investigating extracts from animal organs, Spitzer[7] concluded that the oxidising capabilities of cells are due to an iron-containing nuclein. G. Gola[8] states that the peroxidasic function in plants is due in most cases not only to true enzymes, but also to various iron compounds which are probably katabolic products of more complex compounds such as the hæmatoids. It is stated by G. B. Ray[9] that iron has long been known to show a remarkable resemblance to the oxidising enzymes of the cell. He experimented with living and dead material of *Ulva* and organic acids and found that the addition of ferric sulphate to the living material produced an immediate increase in the rate of respiration, that the addition of ferric sulphate and hydrogen peroxide to the dead material produced carbon dioxide at a rapid rate and that the addition of the same compounds to certain organic acids also produced carbon dioxide at a measurable rate. In the case of the organic acids containing a double bond he found that the changes in the rate of the production of carbon dioxide under the influence of chloroform showed a striking resemblance to the reaction of the organism. The physiology of one of the most widely spread of the iron-depositing bacteria, *Spirophyllum ferrugineum,* has been investigated by R. Lieske,[10] who cultivated it in an inorganic medium containing metallic iron and carbon dioxide (for the production of ferrous bicarbonate) and small amounts of several inorganic salts. He concluded that this species will not grow in media in which ferrous bicarbonate is not present, that it obtains its carbon from the ferrous bicarbonate and that the oxidation of ferrous carbonate to ferric hydroxide is probably necessary as a source of energy for the organism.

Although Baly, Heilbron, and Barker[11] criticised parts of Moore and Webster's work, which is referred to above, they admit that Moore and Webster used true photocatalysts, as the photosynthesis of formaldehyde from carbon dioxide and water can be photocatalysed in visible light by colloidal ferric hydroxide and certain other basic substances. W. Pfeffer[12] states that iron is one of the number of elements which are essential for the growth of plants in all cases and that chlorophyll is not formed in the absence of iron[12] (p. 427). According to B. M. Duggar[13] the best evidence points to the use of iron by every living cell. Hans Molisch[14] states that iron is probably present in every cell.

III.—Properties of Iron Considered in Relationship to Respiration.

The intimate association of iron with respiration, especially under ærobic conditions in which oxidation takes place, is clearly demonstrated in the preceding summary of literature, more particularly in the citations derived from the works of Sacharoff, Macallum, Halliburton, Spitzer, Gola, Ray, and Lieske.*

In all of these cases oxidation is connected with compounds of iron, and it is an established principle of physiology that oxidation whether of complex or simple compounds furnishes energy for the maintenance of vital functions. The existence of two well-defined series of compounds corresponding to the ferric and ferrous oxides is indicative of the ability of combinations of iron to effect either oxidation or reduction under suitable conditions. It is probable that the knowledge of this fact has contributed in some measure to the assignment of the ability of oxidation and reduction in organisms to iron compounds.

W. Pfeffer[12] (p. 299) states that the energy for the first and most primitive organisms might have been afforded by the oxidation of oxidisable inorganic compounds. This suggestion of Pfeffer leads to the consideration of iron and its oxidisable compounds, which are widely distributed in the soils and waters of the earth, as the possible sources of energy of the most primitive organisms, as by the oxidation of iron and ferrous compounds energy is liberated. The oxidations occurring in the rusting of iron are suggestive examples of energy-liberating processes. The literature dealing with the rusting of iron is voluminous and often controversial, but it is fairly generally recognised that the process occurs in two stages. In the first stage either ferrous oxide or ferrous carbonate is formed, and in the second stage the ferrous compound is oxidised to hydrated ferric oxide[15 16]. As Roscoe and

* While this paper was being printed, Mr. H. A. Longman drew the writer's attention to a lecture by Otto Warburg, reported in "Science," LXI., 5th June, 1925, which had just been received. Warburg states that those who have cultivated cells correctly assume that every living cell contains iron, and that life without iron is impossible. He concludes: "Whether we comprehend the idea of respiration in a narrow or broad sense, iron will always maintain its central position as the oxygen-carrying component of the respiration ferment."

Schorlemmer[16] (pp. 1211, 1212) state that native iron occurs as spiculæ in certain basalts and as meteoric iron in considerable masses or in a finely divided state as meteoric dust, it is assumed that some of these forms of native iron are oxidisable, and in that case the rusting process would not be confined to manufactured iron. An example of the probable utilisation of a simple inorganic compound of iron for respiration in a primitive organism is afforded by Lieske's cultural experiments with *Spirophyllum* which are referred to in Section II. In this instance the process of respiration would correspond in a remarkable way with the inorganic oxidation of ferrous carbonate in iron rust, as the oxidisable compounds involved and the products of oxidation are similar in each case.

IV.—Properties of Iron Considered in Relationship to Nutrition.

Of the literature referred to in Section II., the connection of iron with nutrition is shown by Lieske's experiments, which indicate that *Spirophyllum,* a primitive organism, obtains its carbon from ferrous bicarbonate formed by the action of carbonic acid on metallic iron, and by Moore and Webster's experiments which prove that ferric hydroxide is a photocatalyst in the synthesis of formaldehyde. The photocatalytic action of ferric hydroxide in the synthesis of formaldehyde from carbon dioxide and water is significant as formaldehyde is considered to be the first product of the photosynthesis of an organic compound from the two inorganic compounds, carbon dioxide and water. Some of Macallum's conclusions as to the presence of iron in chromatin and the generally known fact that the presence of iron is necessary for the production of chlorophyll are also concerned in the relationship of iron to nutrition. The connection with this subject of Macallum's demonstrations of the presence of iron in chromatin, which are summarised in Section II., is appreciated when it is remembered that chromatin is regarded[17] as the essential constituent of the nucleus, which in its turn is a primary factor in growth and development[18]. Macallum's demonstrations of the presence of iron in chromatin are of further interest, as they may have an important bearing on the origin of life in view of E. A. Minchin's contention[17] (p.18) that very minute particles of the nature of chromatin probably constituted the first forms of life.

There can be little doubt concerning the statement of W. D. Halliburton[19] that the proteins are the most important substances which occur in plants and animals and that protein metabolism is the most characteristic sign of life. It is also generally recognised that the common protein elements are carbon, hydrogen, oxygen, nitrogen, sulphur, and frequently phosphorus. The chemical relations of iron with the protein elements appear significant.

The following table shows some of the inorganic combinations of iron with the protein elements. The nomenclature and formulæ of the less common compounds in the table are derived from Roscoe and Schorlemmer's "Treatise on Chemistry."

The Protein Elements.	Compounds of Iron with Single Protein Elements.	Compounds of Iron with Two or Three Protein Elements.
Carbon (C)	Iron carbide (Fe_3 C) Iron dicarbide (FeC_2)	Ferrous carbonate (Fe CO_3) Ferrous bicarbonate, hypothetical formula $Fe(HCO_3)_2$
Hydrogen (H) ..	Iron absorbs H when heated in that gas. It is possible that a definite compound is formed under certain circumstances	Ferrous hydroxide, $Fe(OH)_2$ Ferric hydroxide, $Fe(OH)_3$ Acid salts of iron, such as diacid ferric phosphate, $Fe(H_2PO_4)_3$
Oxygen (O)	Ferrous oxide (FeO) Ferric oxide (Fe_2O_3) Ferroso-ferric oxide (Fe_3O_4)	Iron hydroxides and iron salts of the oxy-acids (carbonates, nitrates, sulphates, phosphates) could also be included here
Nitrogen (N) ..	Iron nitride (Fe_2N) Ferrous nitride (Fe_3N_2) Ferric nitride (FeN)	Ferrous nitrate, $Fe(NO_3)_2$ Ferric nitrate, $Fe(NO_3)_3$
Sulphur (S)	Iron monosulphide (FeS) Iron sesquisulphide (Fe_2S_3) Iron disulphide (FeS_2) Iron subsulphide (Fe_4S_3)	Ferrous sulphite ($FeSO_3$) Ferrous sulphate ($FeSO_4$) Ferric sulphate, $Fe_2(SO_4)_3$
Phosphorus (P) ..	Phosphides of iron (Fe_2P, FeP, Fe_3P_4, Fe_3P)	Ferrous phosphate, $Fe_3(PO_4)_2$ Ferric phosphate, $FePO_4$ Ferric metaphosphate, $Fe(PO_3)_3$

The table shows the large number of compounds which are formed by iron with the protein elements in both the oxidised and reduced states. It also shows that the iron present in organisms may be capable of a very wide range of chemical activities, as the protein elements are to be regarded as the principal organic elements, because, in addition to their incorporation in the proteins, three of them are also the constituents of the carbohydrates and fats. In view of the above demonstration of the chemical affinities of iron for the protein and carbohydrate elements the possibility is suggested that iron might have acted, or may act, as the assembling agent of the protein and carbohydrate elements or of the compounds containing them. This possibility develops into a suggestion of considerable interest, as it will be shown later that iron rust is a concrete example of a product of iron in which the protein and carbohydrate elements are present.

It is recognised, however, that iron is not the only metallic element which is capable of forming similar combinations with the protein elements. Potassium and magnesium are the only other metallic elements in the same organic category as iron, for together with iron they are the only metallic elements necessary for the growth of plants in all cases[12]. Although potassium and magnesium form similar combinations with the protein elements they do not form the two series of salts such as the ferrous and ferric salts, the existence of which, as pointed out in Section III., is indicative of the ability of combinations of iron to effect either oxidation or reduction under suitable conditions.

The correspondence in the chemical processes involved in the rusting of iron on the one hand and in the initial stages of plant nutrition on the other hand is shown by the fact that in the rusting of iron under atmospheric conditions the combination of water and the fixation of carbon dioxide and ammonia are effected. These three compounds, whose combination or fixation is effected by rusting iron, supply a very high proportion of the material of living matter either directly or indirectly through plants and certain bacteria such as the nitro-bacteria.

According to Roscoe and Schorlemmer[16] (p. 1270) iron rust when completely oxidised is found to have a composition very similar to that of limonite, namely $2Fe_2O_3$, $3H_2O$. The same authors[16] (p. 1270) also state that Van Bemmelen has shown that in reality all the red ferric hydrates are colloidal substances and that the amount of water retained by them depends upon the pressure of the atmospheric aqueous vapour with which they are in equilibrium. Apart from the water content shown by the above formula, which probably applies to the dry product, it is evident that fresh, moist, iron rust is accompanied by considerable quantities of water, the presence of which is one of the conditions necessary for the production of rust.

G. T. Moody[15] has shown that freshly-formed iron rust contains from 12 to 8 per cent. of ferrous carbonate and 36 to 23 per cent. of ferrous oxide. According to Moody and others[16] (p. 1218) the carbon dioxide of the air dissolved in water attacks iron with the formation of ferrous carbonate, which on exposure to air is readily oxidised to ferric oxide. This combination of iron with carbonic acid is similar to that used by Lieske for the fixation of carbon dioxide in the nutrition of *Spirophyllum* (see Section II.).

The fixation of ammonia in the rusting of commercial iron is shown by the presence of ammonia in minute quantities in iron rust. Donath and Indra[20] consider that iron sulphate derived from the oxidation of iron sulphide in iron together with the feebly acid nature of the ferric hydroxide serves to fix traces of ammonia from the air.

It can be contended that, as the ammonia present in rusting iron is derived originally from organisms, its fixation is not of much significance in the problem of the origin of life. Newth,[21] however, states that ammonia is evolved from the fumaroles of Tuscany, that ammonium chloride is formed in the vicinity of active volcanoes and that on boiling aqueous solutions of ammonium chloride dissociation to a small extent takes place and portion of the ammonia escapes with the steam. In view of these statements it would appear that ammonia is not exclusively organic in origin.

Both sulphur and phosphorus are present in small quantities in commercial iron[16] (p. 1242), and as rusting proceeds these two elements would become incorporated in the substance of the rust. From this fact and from the preceding statements it is evident that the rust of commercial iron under atmospheric conditions contains a potential supply of all the common protein and carbohydrate elements in its content of water, carbonate, oxides, ammonia, sulphur and phosphorus.

The question arises as to what extent the chemical processes of iron rust are to be found in nature, as the investigations of the product have been directed chiefly to its occurrence upon manufactured iron. The aspect of this question relating to oxidation is discussed in Section III., where it is assumed that some native irons also undergo oxidation. Sulphur and phosphorus are not confined to manufactured iron, as in the analyses of four different meteoric irons which are quoted by Roscoe and Schorlemmer[16] (p. 1212) it is shown that three of them contained sulphur as well as carbon and two contained phosphorus. In view of these circumstances it is assumed that the corrosion of some of the native irons may not be substantially different from the rusting of commercial iron.

V.—Properties of Iron in Relationship to the Colloid State.

As it is now recognised that the phenomena of life are due to a great extent to the colloidal state of the material in organisms, the relationship of iron to the colloid state requires consideration. Over sixty years ago Thomas Graham[22] pointed out that the colloid state may be looked upon as the probable primary source of the force appearing in the phenomena of vitality. The recent work of distinguished investigators of colloids emphasises the predominant importance of the colloid state in living organisms.

Iron rust is known to be composed chiefly of colloidal material. Colloidal ferric hydroxide is a well-known material which has been prepared in several different forms exhibiting wide differences in physical and chemical properties. Wolfgang Ostwald[23] states that fluid iron hydroxide solutions may be obtained in concentrations characteristic of suspensoids, while on the other hand a jelly-like emulsoid modification of iron hydroxide is known. Although colloidal ferric hydroxide is used in the technique of colloid investigations as a typical, postively charged suspensoid, H. Bechhold[24] states that H. W. Fischer has prepared a negative ferric oxide hydrosol, which forms a deep ruby-red solution, which may at times take up much more than its own weight of oxygen, and that, as it has some other properties of hæmoglobin, Fischer calls this preparation "synthetic active hæmoglobin." Thomas Graham[25] prepared colloidal ferric hydroxide and remarked upon its singular resemblance to venous blood. He also found that these two fluids when further compared resembled each other in the appearance of their coagula and in the feeble agencies which brought about coagulation in each case. These examples derived from the works of Fischer and Graham are mentioned in order to show that colloidal preparations of inorganic iron compounds have some properties resembling those of highly complex organic substances.

VI.—Conclusion.

The possibility of the intimate connection of iron with the origin of life is suggested by the following inorganic properties of iron or its compounds:—

1. The oxidation of ferrous compounds in the soils and waters of the earth, and the oxidation of native iron in the form of spiculæ in certain basalts or in the form of massive or finely divided meteoric iron It is suggested that some of these oxidations could provide the energy of the most primitive organisms in a manner similar to that in which

the oxidation of ferrous carbonate has already been assumed by Lieske to provide the energy for the vital functions of *Spirophyllum.* This process represents physiological respiration.

2. (*a*) The combination of iron with all the common protein and carbohydrate elements, except hydrogen, to form binary compounds, namely, iron carbides, oxides, nitrides, sulphides, and phosphides. Even in the single exceptional case of hydrogen a relationship of a selective character can be established as iron absorbs hydrogen when it is heated in that gas, and it is possible that a definite compound is formed under certain conditions.

(*b*) The combination of iron with the protein and carbohydrate elements to form ternary and quaternary compounds such as iron carbonate, hydroxides, nitrates, sulphates, phosphates and acid salts which collectively contain all the common protein and carbohydrate elements.

(*c*) The combination of water and the fixation of carbon dioxide and ammonia by iron undergoing the rusting process.

The combining and selective relationships with the protein and carbohydrate elements, which are demonstrated above, suggest that iron might have acted, or may act as the assembling agent of the protein and carbohydrate elements or of the compounds containing them. A concrete example of the ability of iron to assemble compounds containing these elements is provided by the rust of commercial iron, which contains a potential supply of all the common protein and carbohydrate elements. Lieske's cultural experiments provide a concrete example of the organic utilisation of the combining property of iron in respect to carbon dioxide as by a process strictly similar to that of the rusting of iron, in which carbonic acid functions, he supplied *Spirophyllum* with carbon.

3. (*a*) The representation of or the very close approximation to the colloid state by iron rust.

(*b*) The ability of ferric hydroxide or ferric oxide to function as principal constituents in colloids of widely different characteristics, such as in suspensoids, emulsoids, positively and negatively charged colloids.

It is suggested that some of the chemical processes, such as oxidation and hydration, which iron and some of its compounds undergo when in contact with oxygen and water, might have initiated or may initiate the primitive colloid state of protoplasm, which in its living state is known to be a colloid complex in which several different forms of colloids, such as suspensoids, emulsoids, sols and gels are present.[26] The chemical principles of these two processes of oxidation and hydration, which are primary factors in the production of the colloid state from iron, are fundamental factors in the maintenance of life.

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The Geological Range of the Tiaro Series.

By W. H. Bryan, M.C., M.Sc., and C. H. Massey.

(*Read before the Royal Society of Queensland, 27th July, 1925.*)

I. Introduction.

The area investigated by the authors lies in the County of Lennox, Queensland, to the west and south of Maryborough, principally on and in the vicinity of the railway line between Mungar Junction and Biggenden.

The earliest geological work in the area seems to have been done by W. H. Rands,[1] who in 1890 published an account of the geology of what he termed the "Tiaro district," an area embracing some 900 square miles, of which he wrote, "The greater part of this country is composed of rocks belonging to the Burrum coal measure series. It is a continuation of the Burrum coal field . . ." Rands examined and reported on coal seams met in this series near Gunalda, on Munna Creek, on Tanyalba Creek at Mount Bopple, on Tinana Creek, and at other places. These coals, he points out, are "non-caking," and differ in this and other respects from typical samples from the Burrum coal field, cited for purposes of comparison. "The coal measures of the Tiaro district are much more disturbed by faults and intrusive rocks than in the Burrum and Howard district, north of Maryborough. The direction and amount of dip is seldom the same over any large area. In many places dykes and masses of intrusive rocks come up through and disturb the coal strata." In the map which accompanied his report Rands considers the base of the coal measures to be a sandstone ("freestone") horizon, with a general N.N.W. trend. To the west of and below this are mapped "Gympie beds."

In his annual report to the Department of Mines in the same year Rands described from the Tiaro district "Granite intruded into the Gympie beds, and on which the Burrum beds rest."

The Burrum beds with which Rands sought to correlate the Tiaro coal beds were at this time, and for many years after, thought to be "On a higher horizon than the Permo-Carboniferous system and on a lower than the Ipswich formation."[2] Later work, as we shall see, has gone to prove that—

1. The Tiaro series is *not* an extension of the Burrum series, but is considerably older; and
2. The Burrum series is not older than the Ipswich series, but considerably younger.

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[1] Qld. Geol. Sur. Pub. No. 59, p. 1.

[2] Jack and Etheridge, Geol. of Qld., p. 300.

The generally accepted explanations of the relationship between the various systems then and now are as follows:—

		Old Classification.	New Classification.
Cretaceous	Upper	Maryborough Series	
	Lower		Burrum Series. Maryborough Series.
Jurassic ..	Upper		
	Lower	Ipswich Series	Walloon Series = Tiaro Series.
Triassic ..	Upper	Burrum Series = Tiaro coal beds	Bundamba Series = Landsborough Series. Ipswich Series.
	Lower		
Permo-Carb. ..		Gympie Series	Gympie Series.

The fact that the Tiaro series was not equivalent to the Burrum series but was considerably older was established by the field investigations of Richards[3] and of Dunstan,[4] who showed that the two series were separated by the Maryborough Marine series, the Burrum coal measures overlying the Marine beds and the Tiaro coal measures underlying them.

The fact that the Burrum series was not older than the Ipswich series but considerably younger was confirmed by Walkom's[5] comparison of the fossil floras of the two series. The same author concluded from the palæobotanical evidence that the Tiaro series was equivalent to the Walloon series. Although this conclusion has met with general acceptance, Jensen[6] has recently expressed the opinion that the Tiaro series is equivalent to the Ipswich series.

One of the present authors [W.H.B.] in company with the late Captain L. R. Blake, M.C., in 1914 made a hurried investigation of the area now under consideration, and found that the Tiaro series were much thicker and more extensive than shown on Plate 5 of the Queensland Mineral Index, and as mapped by Rands in the publication already cited, a considerable extent of Rands's "Permo-Carboniferous" rocks being found to be quite conformable with the overlying Tiaro coal measures and to contain plant remains of Mesozoic types. The total thickness of the Tiaro series, as estimated by Blake and Bryan after this addition, was in the neighbourhood of 12,000 feet.

Dunstan[7] in 1915 showed that at its southern extremity, in the neighbourhood of Landsborough and Caloundra, the Tiaro series is conformably underlain by the massive sandstones of the Landsborough

[3] Aus. Ass. Adv. Sci., 1913, p. 187.

[4] Qld. Govt. Min. Jrnl., 1912, p. 641.

[5] Proc. Linn. Soc. N.S.W., 1918, p. 45.

[6] Proc. Roy. Soc. Qld., 1924, p. 139.

[7] Qld. Geol. Sur. Pub. No. 252, p. 3.

series (which is regarded by him as the local equivalent of the Bundamba series), and that these in turn conformably overlie the northernmost representatives of the Ipswich series.

As a result of their recent field work in the type-district, the present authors now claim that the Tiaro series, as at present defined, is there naturally divisible into four series, three of which are the equivalents of the Ipswich, Bundamba, and Walloon series respectively, and that consequently the Tiaro series is considerably less thick and the Ipswich and Bundamba series more widespread than was formerly realised.

A short statement to this effect by one of the authors [W.H.B.] has been included in a publication recently issued.[8]

II. The Natural Divisions of the Tiaro Series.

The Tiaro series as at present defined extends over an area of many hundreds of square miles, is approximately 12,000 feet thick, and is made up of varied rock types, but several traverses across the area have convinced the authors that the series so-called falls naturally into four divisions. One of these is composed of productive and non-productive coal measures; one lies above the coal measures and thus separates them from the overlying Maryborough (Marine) series, while two lie beneath the coal measures.

The authors suggest that in the light of this natural division the term "Tiaro series" be restricted to the coal measures and that the other series be given the following names, suggested by the localities in or near which they are found typically developed:—

Tiaro series (in old sense) = {
Graham's Creek series
Tiaro series
Myrtle Creek series
Brooweena series.

The Brooweena Series.—This series is typically developed between Brooweena and Aramara on the Gayndah railway. It is made up of shales, sandy shales, sandstones, and conglomerates. Immediately to the east of Brooweena railway station is a remarkable bed of massive purple conglomerates containing red jasperoid and quartzite pebbles. Purple shales are frequently met with in the western (older) portion of the series, but in the eastern portion the shales are much lighter in colour. Although many of the shales on various horizons show fragmentary plant remains, prolonged search only secured one determinate fossil, namely, *Thinnfeldia* sp. Numerous observations of strike and dip were made in the railway cuttings between Lakeside and Hunter's Hut. These showed that the strike is somewhat variable and that it is obviously much influenced by the presence of great granitic intrusions in the western part of the area, and to a less extent by smaller intrusions in the eastern

[8] Proc. Roy. Soc. Qld., 1925, p. 72.

portion. To the west of Boompa and Brooweena it approximates to a north-westerly direction and a north-easterly dip. In the neighbourhood of and to east of the latter place the strike veers still further to the west-north-west, but as Aramara is approached it returns to a north-south direction with a gentle easterly dip which remains the general direction for the remainder of the traverse. An average of fifty-three observations of strike taken in this traverse across the Brooweena series gives a N. 23° W. direction for the general trend of the series. Although steep dips, flattenings, and reverse dips are met with, the series as a whole can be regarded as dipping gently to the east-north-east.

With regard to the relationship of the Brooweena series to the Permo-Carboniferous Gympie series, definite evidence such as would be provided by actual contact was lacking. Marine fossils of Permo-Carboniferous age have been found near Lakeside and Glenbar, and these places lie to the west of the easterly dipping Brooweena series and are thus presumably below it.

Rands[9] regarded the Gympie series as unconformably underlying the Tiaro series, relying upon a section near Curra, where steeply dipping Gympie beds are separated from horizontal "Burrum [Tiaro] beds" by a large porphyritic intrusion. This section is far from conclusive and does not harmonise with Rands's own statement that he has traced a fossiliferous limestone bed of the Gympie series through Gigoomgan for a distance of fourteen miles in a north-north-west direction, *i.e.*, parallel with the Brooweena series, and that further north in the Burrum coal field at Agnes Vale the coal measures pass down conformably into a series of altered rocks which Rands suggests, in order to reconcile this with the Curra section, are younger than the Gympie series and of Permian age.

Although the most westerly outcrop of the Brooweena series occurs to the west of Boompa, where massive white sandstones, fissile shales and mudstones containing numerous indeterminate plant remains are found surrounded by granite, it is improbable that this outcrop marks the lowest horizon of the series. This position is more probably occupied by the purple conglomerates found at Brooweena some three miles further to the east. Hence the old-looking, strongly jointed, very compact, steeply dipping and heavily faulted cherty rocks and andesites found to the west of the Brooweena purple conglomerates may be representatives of the Gympie series and not very metamorphosed examples of the Brooweena series, which is the alternative explanation.

The Myrtle Creek Series.—Lying to the east-north-east of the Brooweena series and exposed in numerous railway cuttings between Hunter's Hut and Thinoomba is a series of rocks which in lithological character form a striking contrast with the shales and sandy shales which it conformably succeeds. This series is made up of very massive siliceous sandstones showing marked current bedding. It is presumably

[9] Op. cit., p. 59.

the massive character and lack of regular bedding planes which are responsible for the fact that in the geological map accompanying the Queensland Mineral Index these rocks are mapped as "granites."

The series is so faulted and disturbed by numerous intrusions of porphyrites that it is difficult to generalise with regard to strike and dip. However, the general direction of the outcrops of this easily recognised horizon as seen at intervals over a distance of ten miles is approximately north-north-west, and hence conformable with the underlying Brooweena series. Almost identical massive white sandstones have been noted by one or other of the authors on the southerly prolongation of this line to the east of Curra railway station and on Widgee Creek and on the northerly prolongation on Duckinwilla Creek and to the south-west of Childers. No fossils of any description have been found in the Myrtle Creek series.

The Tiaro Series.—In the restricted sense suggested earlier in this paper, the Tiaro series outcrops on the Gayndah railway between a point 1½ miles west of Thinoomba, where it conformably succeeds the Myrtle Creek series, to a point about one-half mile to the east of Yerra. The series is composed of soft friable shales, often carbonaceous and sometimes containing coal seams, sandy shales and soft micaceous sandstones. The shales are frequently fossiliferous, the most typical fossil being *Cladophlebis australis.* The general strike is to the north-north-west, although in the more easterly part of the series north-north-easterly strikes are met with. The general dip is a gentle easterly one. The series can be discontinuously followed in a south-south-east direction as far as the northern end of Moreton Island, and has been traced to the north-north-west as far as the Isis River.

The Graham's Creek Series.—To the east-north-east of the Tiaro series, as typically developed and separating it from the overlying Maryborough (Marine) series, is a very considerable thickness of tuffaceous sediments.

Several figures published by Dunstan and by Walkom show tuffaceous rocks as forming the basal part of the Maryborough series, but in view of the wide areal development, considerable thickness and significant nature of these beds, the authors are of the opinion that they should be ranked as a separate series, and have suggested the name Graham's Creek series, owing to their typical development along the stream of that name. The series is made up of trachytic and andesitic tuffs and tuffaceous sandstones, buff, green, and purple in colour, and containing rounded fragments of porphyritic trachytes and andesites. As is often the case with tuffs, it is frequently impossible to decide definitely on the directions of strike and dip, but in all those cases where reliable observations could be made both strike and dip were in conformity with the underlying coal beds of the Tiaro series and the overlying Marine beds of the Maryborough series. The areal extent of the series is considerable, for it is well developed as far north as Delan on the Wallaville branch railway, where Mr. Morton has found a great thickness of volcanics underlying the Maryborough series.

III. Correlation with Other Series.

If for the moment the Graham's Creek series be neglected as forming passage beds between the Tiaro series and the Maryborough series, the remaining series of the group under discussion form a triad which, composed as it is of two sets of fossiliferous shales separated by one of massive barren sandstones, is frequently met with in the developments of Lower Mesozoic rocks, both in Queensland and New South Wales. Thus in both the Sydney and Clarence basins in the latter State, and in the Ipswich, Brisbane Valley, Wide Bay, and Carnarvon areas in Queensland, the same threefold lithological development is met with. Such uniformity of development strongly suggests contemporaneity of deposition, the change from fossiliferous shales to barren sandstones and back again to shales apparently indicating widespread changes of some geographic or climatic controlling factor. Such a conclusion is supported by other facts. Thus in Sydney, Carnarvon Range, and the Wide Bay areas there is general conformity between the lowest shales of the Mesozoic sediments and the underlying Permo-Carboniferous series, although of course the different junctions may represent disconformities of different values.

In the light of these facts it is natural that the older geologists should have regarded the Lower Mesozoic rocks of the two States as being confined to three series, a lower and an upper series of fossiliferous shales, and a middle series of barren sandstones.

Some years ago Dr. A. B. Walkom made a series of detailed palæontological investigations into the several developments of Lower Mesozoic sediments in the eastern States of Australia, as a result of which he concluded that the lithologically similar threefold divisions of the Sydney, Clarence, and Ipswich areas occupied quite different positions in the geological time scale, the middle sandstones, for instance, being assigned to three distinct horizons. The palæobotanical evidence thus appears to be directly opposed to the simple generalisation of the earlier geologists which so nicely and effectively correlated our Lower Mesozoic deposits.

Although Dr. Walkom's conclusions have met with general acceptance, Jensen[10] supports the old classificatory scheme in that he correlates what he terms the "Ipswich series" of the Carnarvon Range area with the Narrabeen shales of the Sydney basin. The Chief Government Geologist of this State, basing his opinion on both lithological grounds and on field mapping, still adheres to the view that the threefold divisions of the Clarence series are respectively equivalent to the Ipswich, Bundamba, and Walloon series,[11] while the authors have been privileged to see the manuscript of a paper by Mr. J. H. Reid, in which he has arrived at the same conclusion as a result of a comparative study of coal analyses from the two areas.

[10] Qld. Govt. Mining Jour., 1921, p. 405.

[11] Verbal communication.

In correlating the lacustrine sediments of the Wide Bay area, there is no room for such perplexing doubts, for the palæobotanical and lithological evidence both point to a correlation of the Brooweena, Myrtle Creek, and Tiaro series with the Ipswich, Bundamba, and Walloon series respectively, and this conclusion is strongly supported by the facts of geographical distribution.

The detailed evidence for this correlation is as follows:—

Palæobotanical Evidence.—Fossil plants were collected from four points, A, B, C, D, three of which, A, B, C, were within the Tiaro series in the restricted sense, the fourth, D, being in typical beds of the Brooweena series. These specimens were kindly examined by Dr. A. B. Walkom, who has forwarded the following determinations and comments:—

"Locality A.—

Equisetites rotiferum Tenison-Woods.

Taeniopteris spatulata McClelland.

Elatocladus cf. *plana.*

? *Sphenolepidium* sp.

Equisetites rotiferum is a typical Walloon fossil. The examples of *Taeniopteris spatulata* are similar to that originally described by McCoy as *T. Daintreei,* and also to specimens described from the Burrum series (Qland. Geol. Survey, Pub. 263, p. 36, Pl. 1, fig. 9). The coniferous fragments referred to *Elatocladus* may be compared with specimens of *E. plana* described from the Walloon series and also from the Burrum series. The specimens named *Sphenolepidium* sp. are similar to that previously figured from the Burrum series (loc. cit., Pl. 2, fig. 3).

Locality B.—

Cladophlebis australis.

Locality C.—

Equisetaceous stems (probably *E. rotiferum*), similar to those from Locality A.

Locality D.—

? *Thinnfeldia* sp. (apical portion of a frond).

? Insect wing.

It is to be noted that all the species from localities A, B, and C are species occurring in the Walloon series in other areas, and also that the only recognizable plant from locality D is a *Thinnfeldia,* which genus is, so far as we know at present, confined to the Ipswich series in Queensland. This confirms the suggestion that the Tiaro series includes representatives of both Ipswich and Walloon series."

The following key shows details of the localities from which the specimens were obtained:—

A. In gully, near road, S.E. corner of Portion 37v, Parish of Gutchy, County of Lennox (4 miles north of Theebine).

B. On road between Portions 24F and 25F, Parish of St. Mary, County of Lennox ($2\frac{1}{2}$ miles west of Owanyilla railway station).

C. Railway cutting immediately west of Thinoomba railway station.

D. Railway cutting 2 miles west of Aramara railway station.

Lithological Evidence.—The thin-bedded micaceous and carbonaceous shales and sandy shales which make up the Tiaro series (in the restricted sense) can be correlated only in a very general way with the Walloon coal measures as developed in the type area. They resemble them in their weak resistance to weathering and consequent lack of outcrops, but some lithological types which are well developed in the Walloon-Rosewood area, such as the red and brown fossiliferous clay ironstones, appear to be absent from the Tiaro series. On the other hand, the curious cone in cone limestones described by Reid[12] from the Walloon series are well developed in certain portions of the Tiaro series, as in the S.E. corner of Portion 37, Parish of Gutchy, four miles north of Theebine.

The evidence furnished by the several analyses of coal seams from the Tiaro series is at first sight distinctly against a correlation of that series with the Walloon series, the nature of the coal being much more like that of the Ipswich coals than the Walloon coals, as the following average analyses taken from the Queensland Mineral Index show:—

	Tiaro.	Walloon.	Ipswich.
Moisture	4·4	6·0	1·5
Volatile matter ..	20·0	39·0	27·0
Fixed carbon	61·8	44·0	58·5
Ash	13·8	11·0	14·0

However, it should be borne in mind that a feature of the Tiaro coal field which has been emphasized by Rands,[13] by Dunstan,[14] and by Jensen,[15] and which is indeed obvious to anyone traversing the area, is the great number of faults and of intrusions and their effect upon the coal seams. In the neighbourhood of Mount Bopple this alteration in the coal seams has been so intense as to produce anthracite and graphite. This is very different from the Walloon coal field where, as Reid[16] has pointed out, in the type area there is "entire absence of intrusive rocks . . . and freedom from disturbance by faulting." From the neighbourhood of Mount Alford, however, Reid[17] has described a coal seam undoubtedly of the Walloon series which is associated with sills

[12] Qld. Geol. Sur. Pub. 272, p. 16.
[13] Qld. Geol. Sur. Pub. 59, p. 2.
[14] Qld. Min. Index, p. 761.
[15] Proc. Roy. Soc. Qld., 1924, p. 139.
[16] Qld. Geol. Sur. Pub. 272, p. 18.
[17] Qld. Gov. Min. Jour., 1922, p. 470.

of trachyte. The analysis of this coal is more like that of the typical Ipswich coal than that of the typical Walloon, and is very similar to that of the typical Tiaro coal. The analysis is as follows:—

Moisture	6·4
Volatile matter	18·5
Fixed carbon	63·2
Ash	11·9

The differences in the chemical analyses of the Walloon and Tiaro coals may thus be reconciled, if it be granted that the comparatively low values for the volatile constituents of the latter coals are the result of the numerous intrusions and the movements to which they have been subjected. It should be noted, however, that Jensen, while realising this possibility, retains the opinion that the Tiaro series is of Ipswich age, as the following quotation will show:—"The Tiaro coal measures are, in the writer's opinion, of Ipswich age, the same as the Esk beds. They are intruded by dykes of acid igneous rocks, and as a result of the intrusions they are much folded and the coals are high in fixed carbon."[18]

The lithological evidence in favour of a correlation of the Myrtle Creek series with the Bundamba series is strong. The siliceous nature, massive character, current bedding, mode of weathering, and consequent nature of outcrops of the two series as typically developed are practically identical.

The shales, sandy shales, sandstones, and conglomerates of the Brooweena are lithologically similar to those of the Ipswich series, and this is especially true of those shales containing numerous plant fragments which occur to the west of Aramara.

The Brooweena series is, however, conspicuously different from the Ipswich series in that it lacks those coal seams which have made the latter series of so much economic importance.

Geographical Distribution.—Dunstan[19] has shown how the Tiaro series can be followed to the south and east continuously down the Queensland coast to Caloundra, and that to the west of and below the series is a development of massive sandstones of the Bundamba type which he has named the Landsborough series. These reach from the Obi Obi Creek to Toorbul Point. The position and trend of this belt of sandstones is well shown by Walkom,[20] whose map also shows how the series (there called the Bundamba series) is cut off to the north by a development of Palæozoic rocks. The field work of the authors shows that the outcrop of the Myrtle Creek series forms a belt of approximately the same width as, trends in the same direction as, and is in alignment with, the Landsborough series. To the west of this and occupying the same relative position to the Myrtle Creek series as the Ipswich

[18] Proc. Roy. Soc. Qld., 1924, p. 139.
[19] Qld. Geol. Sur. Pub. 252, p. 3.
[20] Proc. Linn. Soc. N.S.W., 1918, Pl. II.

series to the Landsborough series is the Brooweena series. The evidence of field mapping and geographical distribution is thus strongly in favour of correlating the Tiaro, Myrtle Creek, and Brooweena series with the Walloon, Bundamba, and Ipswich series respectively (see map).

Walkom[21] has commented on the great thickness of the Walloon series as determined in the Roma district (11,000 feet) and in the Tiaro district (12,000 feet) as compared with the thicknesses of the Bundamba series (3,000–5,000) and the Ipswich series (2,000–2,500 feet). Since Walkom's comment Reid[22] has estimated the thickness of the Walloon series in the type district as at 6,000 feet. Such an estimate was difficult to reconcile with that from the Roma district until Jensen[23] divided the so-called Walloon series there into the equivalents of the Ipswich (4,000 feet), Bundamba (3,000–5,000 feet), and Walloon (5,000 feet) series. The investigations of the present authors in the Tiaro area show that the 12,000 feet estimated as the thickness of the Tiaro series in the old sense may there also be split into three series, thus bringing the thicknesses of the different occurrences of our lower Mesozoic deposits into harmony. Thus we see that the work of the past few years has shown—

1. That the thickness of the Walloon series and its equivalents was neither so great nor so variable as was thought; and
2. That the equivalents of both the Ipswich and Bundamba series outcrop over much greater areas than had been previously realised.

IV. Earth Movements and Igneous Activity.

This aspect of the geology of the area has already been briefly touched on by one of the authors.[24]

The earliest event of importance in this connection within the area seems to have been the intrusion of great granitic masses. These may be studied in the railway cuttings to the east of Lakeside and of Boompa. These outcrops appear to form a neck connecting two very extensive outcrops of granitic rocks lying to the north-east and south-west respectively.

Petrologically the representatives of this great development actually examined by the authors may be described as medium-grained grey granodiorites. Micro-sections show the presence of quartz and two felspars, one of which, a basic oligoclase, predominates over orthoclase, while the ferromagnesian minerals are represented by both biotite and hornblende, the former, however, being in considerable excess.

With regard to the age of these granodiorites in the Tiaro district, Rands[25] is of the opinion that they intrude the Gympie beds and that

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[21] Proc. Linn. Soc. N.S.W., 1918, p. 58.
[22] Qld. Govt. Min. Jrnl., 1922, p. 467.
[23] Proc. Linn. Soc. N.S.W., 1923, p. 157.
[24] Bryan, Proc. Roy. Soc. Qld., 1925, p. 72.
[25] Qld. Geol. Sur. Pub. 58, p. 8.

the "Burrum [Tiaro] Beds" rest upon them; but Jensen,[26] writing of the area immediately west of that examined by the authors, has stated that "the rhyolites, dacites, quartz porphyries, and granites are in the main Mesozoic." In the same paper Jensen points out that "Mr. Morton's work has vastly extended the granitic intrusions of Triassic and post-Triassic age in Queensland." There seems to be a growing recognition that the intrusion of large masses of granitic rocks played an important part in the early Mesozoic history of certain portions of Queensland, and especially in that of the Wide Bay and Burnett areas. Such a conclusion is certainly strengthened by the evidence in the Tiaro district, for, while the Tiaro series (in the restricted sense) may, as Rands avers, rest upon the granites, there can be little doubt that the underlying Myrtle Creek series has been intruded by them. This is well shown in the neighbourhood of Cabbage Tree Mountain, where the massive sandstones have been considerably disturbed and altered to quartzites in the neighbourhood of a large intrusion of granodiorite.

That the granitic intrusions of the area may be still later is indicated by Dunstan's[27] geological note describing the Mount Bopple area, in which he states, "Syenitic granite forms the top of the mountain, altered Trias-Jura [Tiaro] coal measures occurring around the base. Where the coal measures are much crumpled and intruded by dykes of andesite and syenite, the coal seams have been altered to anthracite and graphite." The same authority, in his geological note under "Tiaro," writes[28]:—"The coal measures are much disturbed and rest on the Gympie formation, both series being intruded by the granite."

One of us (W.H.B.) has stated that "the attitude of the Mesozoic strata in the neighbourhood suggests that the intrusion post-dated their folding—*i.e.*, that the intrusion took place in late Mesozoic or even early Tertiary times," but added that "in the absence of more detailed evidence the writer will not urge such a radical hypothesis."

Although no intrusions of a granitic type have been discovered by the present authors actually within the Tiaro series, there are present very numerous dykes of porphyrite and allied rocks of a hypabyssal nature. These vary from hornblende-porphyrites, in which the phenocrysts of the amphibole measure almost one inch in length, to very compact fine-grained rocks which might be best described as intrusive andesites. Microsections of typical specimens support this conclusion for the base in which the phenocrysts are set usually approaches the pilotoxitic nature characteristic of andesites.

With regard to the distribution of these porphyritic intrusions Rands[29] pointed out that while they are numerous in the Tiaro district they are not found in the Burrum district. At that time Rands regarded the Tiaro coal measures as a southerly extension of the Burrum series,

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[26] Proc. Roy. Soc. Qld., 1924, p. 143.

[27] Qld. Min. Index, p. 761.

[28] Op. cit., p. 949.

[29] Qld. Geol. Sur. Pub. 59, p. 2.

and hence explained the difference as a strangely restricted *geographical* distribution of the intrusives, but the discovery that the Burrum beds are considerably younger than the Tiaro series showed that the distribution was probably a reflection of the *age* of the porphyrites. This is emphasized by the fact that the intrusives are not found in the Maryborough Marine series. Hence the age of the porphyrites must be regarded as late Jurassic or early Cretaceous. The Mount Bopple area would appear to show that the large granitic (syenitic) intrusions are also of this age. An important feature and one of economic significance is that where the intrusions are most numerous the Tiaro coal measures are also much crumpled and heavily faulted.

The Graham's Creek series of tuffaceous sediments probably for the most part post-dated the porphyritic intrusions, but it is probable that the earlier more basic tuffs were contemporaneous with the intrusions of porphyrite and andesite, while the later acidic tuffs seem to have immediately preceded the Maryborough Marine series into which they appear to pass.

The authors know of no parallel in Australia with the Graham's Creek series of tuffs, but the Upper Jurassic and Lower Cretaceous history of New Caledonia is closely comparable with that of the Tiaro area in that it was characterised by subsidence, sedimentation, and the extrusion of rhyolites and andesites.[30]

Thus the great granitic and lesser porphyritic intrusions appear to have taken place during the slow but intermittent subsidence during which the lacustrine sediments were deposited, and the eruption of the volcanics which gave rise to the Graham's Creek series coincided with the reversion from the terrestrial and lacustrine conditions which had persisted since Palæozoic times to the Marine conditions of deposition which resulted in the formation of the Maryborough series.

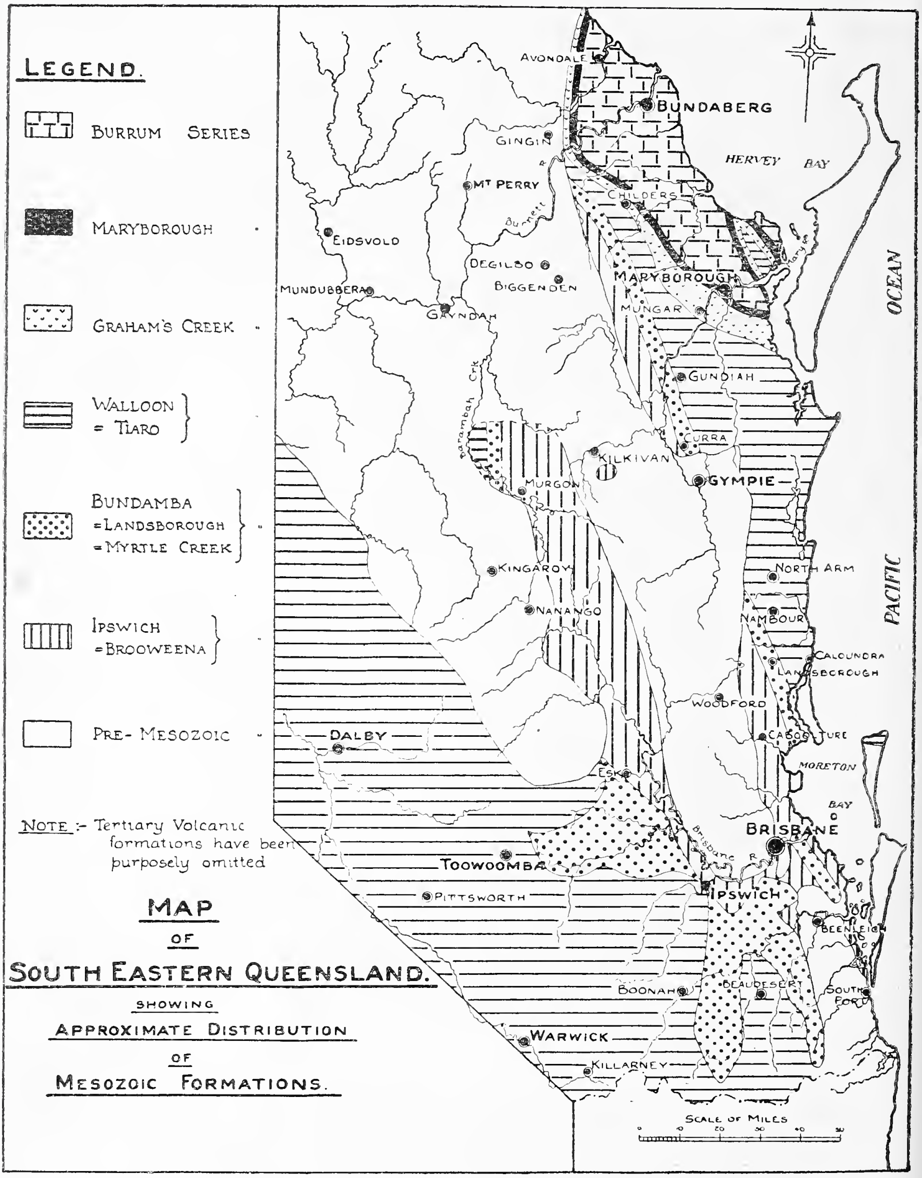
Although, as we have seen, the large intrusions of the granodiorites and the smaller intrusions of the porphyrites was accompanied by considerable local crumpling and faulting, the only major earth movement of which there is evidence seems to have taken place after the deposition of the Burrum series. One of the authors (W.H.B.) has described the nature of this folding in a previous publication, so that it may be dismissed with a few brief remarks. The Brooweena, Myrtle Creek, Tiaro, and Graham's Creek series, which have a general north-north-west strike and a gentle dip to the east, may be considered the comparatively flat eastern limb of a large anticline, the axis of which was in the neighbourhood of Gayndah. Immediately to the west of the Tiaro area is the steep western limb of a similar and parallel anticline. These two anticlines seem to form part of a huge denuded ge-anticline whose axis appears to have extended from the neighbourhood of Beaudesert towards Rockhampton. This ge-anticline appears to have been formed as the result of heavy thrusts from the Pacific Ocean, for the westerly dips are usually steeper than the easterly.

[30] See Benson, Transactions of the New Zealand Institute, 1924, p. 124.

EXPLANATION OF MAP.

The accompanying map of South-Eastern Queensland, showing the approximate distribution of Mesozoic formations, is in large part the result of a compilation of material from many sources, and in part the result of field investigations by the authors.

It should be noted that the large coastal islands shown in the map are, with the exception of the northern end of Moreton Island and a few small outcrops on the other islands, so covered with sand dunes that mapping of the underlying formations is impossible, although it is a reasonable assumption that these are for the most part Mesozoic.



Movement of *Mimosa Pudica* as affected by Anaesthetics and Other Substances.

By D. A. HERBERT, M.Sc., Department of Biology, University of Queensland.

(*Read before the Royal Society of Queensland, 31st August,* 1925.)

Anæsthetics have been defined as those substances which act on living cells in such a way as to abolish temporarily those activities which we regard as manifestations of life[1] or which cause temporary insensibility to external impressions. Most of the earlier work on anæsthesia was carried out on animal tissue, and when apparently similar response was found in plants by the early workers the analogy led to the use of the term anæsthesia in plant physiology, and to the inference that a nervous system similar to that of animals existed in plants. The phenomenon of anæsthesia depends on so many factors that a simple definition such as either of those given is not sufficient to explain it. It includes effects on enzymes, chemical changes and permeability, along with the resultant effects on irritability and general metabolism. On the whole, the action of anæsthetics on plant tissue with respect to permeability, respiration, and such processes is very similar to that on animal tissue, but when the effect on movement is considered the case is very different.

Clemens* in 1847 found that *Mimosa pudica* and stamens of *Berberis* lost their irritability on exposure to ether. Six years later Leclerc* found that *Mimosa pudica* lost its irritability under the same treatment and that it later recovered if the dose were not excessive. This work has been repeated and confirmed by later workers, and a firm foundation laid for the belief that anæsthesia in plants is very similar to that in animals.

It is the object of this work to investigate the effect of ether, chloroform, and other reagents on the irritability and movement of *Mimosa pudica* and to determine the extent and nature of the action of anæsthetics on plant movement. In the course of the experiments a number of interesting points were brought out which contribute to our knowledge of the movement of this plant, but the main point is that they indicate that there are considerable differences in the effects of anæsthetics on it and on animals.

Mimosa pudica was chosen not only because it is the classical example of a plant showing a marked power of movement, but because

* Cited by Bonns[2].

at Los Baños, Philippine Islands, where most of the work was carried out, it is one of the commonest weeds, and every experiment could be carried out on a large scale under natural conditions. Other sensitive plants, such as *Biophytum sensitivum* and *Averrhoa bilimbi* (Oxalidaceæ), were available, but were not used, partly because of their slower movements and partly because their response is very variable, depending on the age of the leaves. Numerous legumes, such as *Samanea* (*Enterolobium*) *saman, Leucaena glauca,* and others show similar movements, but to a less marked degree, and need a violent stimulus, such as the scorching of the terminal leaflets, before they respond with reasonable rapidity.

Movement in *Mimosa pudica.*

The characteristic movement of *Mimosa pudica* makes that plant a particularly suitable subject for the study of the effects of stimuli. When it is stimulated by shaking or other means the leaflets of the pinnæ fold vertically, the palmate pinnæ approach one another, and the petiole droops. The movement is due to response in the pulvini of the respective parts.* Pfeffer[3] showed that the movement was due to a fall in turgor in the cells on the under side causing transference of fluid from the cells to the intercellular spaces, the consequent deformation resulting in a contraction of the under side. This contraction is the cause of the curvature of the pulvinus. Vines and other authors advanced the view that the movement is caused by an active protoplasmic contraction. Brown[5] has shown that, in pulvini which have been killed before they have had time to contract, the movements may be artificially produced by varying the osmotic pressure in the cell. A large number of leaves were killed with boiling water. A number of leaflets showed incomplete curvature, having been killed before the contraction could be completed; these were run through various stages of alcohol and transferred to xylol. Curvature was completed by this treatment. On being transferred back through the same stages to water, they went back to their original position. This unbending did not take place when those in which curvature had been completed were subjected to the same treatment. Since the effect of replacing the water is to reduce the osmotic pressure, Brown's experiment goes to show that the curvature may be produced by the artificial lowering of osmotic pressure. Blackman and Pain[6] showed that a slight exosmosis of electrolytes is associated with the contraction, but that this is insufficient to account for the sudden drop in turgor of the cells. They regard the loss of turgor as due to the disappearance or inactivation of a considerable portion of the osmotic content of the cells.

The sudden extrusion of water into the intercellular spaces is the first stage in the action when the plant is stimulated. The impulse is transmitted from the stimulated pulvinus to the next one. The transmission may take place through the entire leaf and sometimes beyond it to other leaves on the branch. It was Haberlandt[7] who first showed

* For general discussion, *see* Pfeffer[3] and Jost[4].

that transmission was hydromechanical. Dutrochet[8] found that removal of the cortex did not prevent transmission, but the later and more elaborate work of Haberlandt showed that it took place through tubular cells in the phloem analagous with the tannin canals of other Leguminosæ. According to Haberlandt the sudden extrusion of water in the pulvinus results in a pressure on the turgid conductive cells which is passed along them.

The criticism against Haberlandt's theory, left a more or less open question by Jost (*loc. cit.*), is that in an experiment where the cortex had been completely removed transmission still took place. Pfeffer's experiments led him to believe that the xylem was the channel of conduction.

Pfeffer found that transmission of stimulus took place through petioles part of which had been chloroformed. Haberlandt's experiments showed that it also took place through parts which had been killed by scalding. More recently Bose,[9] who does not agree with the hydromechanical theory of transmission, has advanced the argument that these parts had not actually been killed by the scalding or chloroforming (as the case may be) and that we are dealing with a protoplasmic transmission of excitation and not a case of transmission of stimulus. He doubts whether in either case the tissue has been killed and quotes Kuhne's experiment on conduction of excitation in a nerve in a frog's sartorius. Kuhne threw the upper part of the muscle into a state of heat rigor by dipping in warm oil. On cutting the rigored portion with scissors, the half which remained normal twitched, showing that the excitation nerve fibres could still be mechanically excited between the rigored and dead muscle fibres. In this case and in the cases of Haberlandt's scalded tissue, the conducting tissue, he says, was not killed. Bose's point of view is of interest because of the vast amount of data which he has collected in the subject of irritability of *Mimosa*. He supports his argument by citing the case of *Biophytum sensitivum*, where an old leaf whose leaflets have lost their motility on account of age can still conduct an excitation through its petiole, inducing a fall of the leaflets in a neighbouring young leaf. There are two points which have been overlooked here. The first is that leaflets may lose their power of response while still retaining their sensitivity to stimuli. The second is that Haberlandt pointed out in his work that in *Mimosa* was found the only case of this type of conduction; he did not claim that it existed in *Biophytum*, which does not possess the conducting tissue.

The experiments of Ricca[10] on an allied species of sensitive plant, *M. Spegazinnii*, have led him to conclude that stimulation results in the setting free of a stimulating substance which travels through the wood with the transpiration current. No such conduction takes place in the phloem of the stem. Ricca's experiments have been repeated and confirmed by Snow[11] using *Mimosa pudica*. In a preliminary paper (Herbert[12]) it was shown that in the case of the petioles conduction does take place through the phloem and not through the xylem. As the experiments were incidental to the main work of investigating the effects of anæsthetics and as leaf material alone was used for that purpose, the question as to mode of conduction in the stem was not investigated. The experiments were regarded as supporting evidence in favour of Haberlandt's theory. As they did not coincide with the results of Ricca, Snow (*loc. cit.*) repeated them and confirmed them also. It therefore appears that the phloem of the petiole is the path of conduction, while in the stem the wood is responsible. As will be pointed out later, however, the wood is not entirely responsible for the conduction taking place in the stem.

As the question of conduction of stimulus is of great importance in the experiments to be described, an account of the observations on which the conclusion as to this function of the phloem and of the conditions under which transmission takes place is necessary.

It was found that there is a great possibility of experimental error because of the fact that when a leaf is shaken the *shaking* may take place in other parts and the effect be mistaken for a transmission of stimulus. Cutting may also produce a shaking in neighbouring and even in remote leaves. If heat or chemical stimulus is applied the same trouble—the action of the stimulating agent being produced in other parts—is very likely. In these experiments, therefore, precautions were taken that no such error could occur. When the stimulus was mechanical shock or wounding, the leaf was so fastened to a firm support that there was no possibility of shaking beyond the attachment when either end was disturbed. When chemical or heat stimulus was applied a shield was attached to the leaf (or part of the leaf) so that diffusion or radiation to other parts could not take place.

When a stem or petiole is cut a drop of liquid appears almost immediately on both surfaces. In the case of the petiole this occurs to the same extent whether the leaf is erect or relaxed, and it appearance is too rapid to show from which particular region the exudation has taken place. If it is quickly removed, however, the next drop forms but slowly and with the aid of a hand lens it can be seen that it emerges from the phloem region. Haberlandt has pointed out that the turgidity of these cells must be a necessary condition for the hydromechanical transmission of stimulus, and the fact that on a wilted plant transmission is feeble bears out his contention. According to the Haberlandt theory, if these tubular cells have their turgidity destroyed by ringing, no transmission should take place. Ricca, however, has shown that in the case of *M. Spegazzinii* that a severed stem is able to transmit a stimulus through a short column of water to another portion of stem. The conclusion that a hormone is responsible for this action is borne out by Snow's confirmatory work on *M. pudica.*

Transmission in the Petiole.

The decortication method of Dutrochet was first tried, but the removal of all the tubular cells was rather difficult without the removal also of part of the xylem. This was, however, done, and in the large number of plants tried it was found that no transmission took place through petioles so treated. The lack of transmission was not only shown by the relatively mild stimulus given by mechanical shock, but also by the violent stimulus given by the cutting of the pinnæ or of the leaflets.

The proving of absence of transmission in the xylem would not be accomplished by the removal of the xylem of a petiole, because it would prove only whether the elements external to the xylem were active in this respect or not. Removal of the wood is an easy operation. A section was taken out of a number of petioles, but it was found that leaves so treated frequently failed to recover from the first excitatory fall produced during the operation of dexylification. It was found, however, when the cavity was filled with water and the petiole kept wet, that recovery took place. In such cases the transmission was almost as rapid as in a normal leaf. The same was observed where the petiole was almost cut through by a razor. As long as some of the tubular cells remained uncut transmission took place.

If a section of a stem with the pulvinus and petiole of an amputated leaf is placed in water re-erection takes place. If, now, the water be heated, an excitatory fall is produced at about 67° C. This is slightly preceded by a rapid flow of small air bubbles from the phloem region. This air is derived from the intercellular spaces of the pulvinus and the extrusion, though it does not prove that the bubbles travel in this region in the living plant (because in this experiment the heat causes expansion), goes to show that they are the normal outlet for any water movement in the reacting tissue.

Transmission in the Stem.

In view of Ricca's work on conduction, and the conclusive proof advanced by him that conduction in the stem takes place through the wood, the Haberlandt theory stands in danger of being discarded. Snow (*loc. cit.*, p. 353) remarks that the statement of Haberlandt that a cut into the phloem of the stem suffices to start conduction is incorrect. On the same page, however, he states that in some cases cuts which penetrated deeply into the phloem set up a "high speed" conduction of an absolutely different type from that produced when the wood, the Haberlandt theory stands in danger of being discarded. Snow (*loc. cit.*, p. 353) remarks that the statement of Haberlandt that a cut into the phloem of the stem suffices to start conduction *pudica*.*

* H. H. Dixon ("Nature," 114, p. 626, 1924), while agreeing with Snow's confirmation of Dr. Ricca's work on the movement of the stimulating substance in the wood, considers that Ricca's explanation is sufficient to cover also the phenomena of leaf conduction and high-speed conduction in the stem. Snow's further work on *Mimosa Spegazinii* in Sicily ("Nature," 115, 82-83, 1925) has shown that it can hardly be possible that high-speed conduction is caused by movements of water in the vessels.

A number of experiments carried out in Brisbane in December, 1924, and January, 1925, throw a little more light on the problem. A number of internodes were ground in a mortar with a few drops of water and the extract, containing Ricca's hormone, applied to the cut bases of twigs of *Mimosa pudica*. These twigs had been allowed to stand in water in diffuse light for some time and were fully recovered. A short time after the application of the extract the leaves fell and shortly afterwards the leaflets closed. The time varied with different twigs, generally being about twenty seconds for the curvature of the first pulvinus, and another twenty for the closing of the leaflets. This illustrates the normal type of conduction investigated by Ricca. The bark of a living *Mimosa* plant was then subjected to pricking by a fine needle. The pricks were made round the whole circumference of the stem and so regulated that they did not reach the wood. It was found that when a prick was made directly beneath a leaf (and within a reasonable distance) that an almost instantaneous fall usually took place. At other places no response was made to the pricks. The leaf fall was of the type described by Snow as associated with high speed conduction. This high speed conduction is remarkably similar to the high speed response of a leaf which is cut and quite different from the rather leisurely response to the action of the hormone. It is significant, too, that cutting or piercing is necessary to set up this rapid type of conduction; a burn is not effective, though it will produce "normal" conduction.

It appears, therefore, that we are not in a position to discard Haberlandt's theory entirely. That a hormone is present and that it is capable of travelling in the water stream in the stem and causing transmission of excitation is beyond doubt. The most obvious movement, however, is that of the leaves in which movement, both acropetal and basipetal, takes place so rapidly that movement of a hormone along the channels of water movement is out of the question. Snow has shown that the hormone is incapable of producing high speed conduction, and his results have been confirmed. Haberlandt's theory of hydromechanical transmission of excitation must therefore remain as the most satisfactory explanation of high speed conduction yet advanced, while Ricca's work accounts for the transmission in the so-called normal conduction.

The main importance of these experiments in so far as they relate to the present work is that they indicate the precautions necessary for the subsequent experiments.

The Quantitative Effect of Stimulus.

Before considering the movement of the leaves or their parts as an index of the effect of stimuli, however, it is necessary to consider the quantitative effect of shock. *Mimosa pudica* is subject to fatigue and more than three or four consecutive stimuli (each applied when the leaf has just recovered from the last shock) are apt to produce a marked falling off in the amount of response. In typhoon weather leaves may be seen blowing violently about in the wind but without any response to the shaking which normally produces rapid action.

The effects of different stimuli vary, but they can be resolved into two types which for convenience may be termed (*a*) *Simple shock response* and (*b*) *Injury response.* The former is typified by the response shown when a leaf is struck, and the latter when it is injured either mechanically or by chemical stimuli. Naturally the two types grade off into one another, but the effects of most stimuli can be classified in this way.

In the experiments to be described the following stimuli were studied:—Shaking, wounding, heat, various gases (including anæsthetics) and solutions.

Shaking.

The effect of shaking or striking a leaf of *Mimosa* varies with the intensity. A blow may be made light enough to produce practically no effect on the part struck. There is, however, a definite point beyond which any more violent mechanical shock (short of actual injury) will not produce more rapid response. If the terminal leaflets are struck and the shock is sufficiently violent they close and the pulvini of the other leaflets of the pinnæ and of the petiole assume the sleep position. The mechanism of this is sufficient to show that this is *not a case of transmission of stimulus because the primary pulvinus frequently curves before the intervening leaflets between it and the struck leaflets have folded together.* In experiments described below, where there is undoubted transmission of stimulus the stimulated leaflets close first, then there is a progressive movement down the pinna, up the other pinnæ, and down to the primary pulvinus. When the petiole or part of the pinna is so fixed to a firm support that one part can be shaken independently of the other it is found that the feeble stimulus given by shaking is not transmitted beyond the clamp. The leaflets on either side may be struck or shaken without any effect being produced on the other side. When a leaf is shaken or struck therefore a excitatory movement is produced because of the direct stimulus to each pulvinus and not to transmission from the leaflets which happen to have been struck.

Wounding.

In studying wounding the same precaution against shaking must be observed. The fixing of the leaf must be firm enough to hold the petiole or pinna securely while at the same time not producing a ligature effect, because a ligature will prevent transmission if made too tight. When a leaf so arranged is wounded by cutting or pricking, the stimulus is transmitted beyond the clamp and the time of recovery is proportionately longer than in the case of a leaf relaxed by shaking.

The rate of recovery in leaves which had been wounded and leaves which had been struck was compared and the first ten cases out of the large number observed were as follows:—

Table I.—Time of complete recovery in minutes.

Struck	10	10	11	8	8	10	11	12	11	10
Wounded	17	21	17	29	20	19	20	20	21	20

The figures for the wounded leaves represent the time which it took for the leaflets to recover. It was noticed, however, that the effect of the injury was not shown in the recovery of the adjacent leaves on the stem which had fallen when the experimental leaf was cut. The following table shows some typical figures; it will be seen that recovery of these leaves is comparable with that of leaves which have been shaken.

Table II.—Time of complete recovery in minutes.

Shaken	10	9	9	11	9	9	10	9	11	9
Indirectly affected by wounding	9	10	10	9	9	11	10	8	9	9

Obviously, therefore, the effect of a wound is much more profound than that of a blow. An important point shown by these figures, however, is that the *parts to which a stimulus has been transmitted behave in the same way as they would if they had been struck,* i.e., the violence of the stimulus is local.

The more violent the stimulus the greater the amount of transmission. In the case of the relatively feeble shock stimuli the transmission is practically nil. With a wound, however, it may be great enough to cause a disturbance extending to the leaves further up and down the stem.

Some interesting observations on the path of the transmission were afforded by subjecting leaflets and pinnæ to varying amounts of injury. Some of these are included in the following table. The times are in seconds.

Table III.—Rate of response and recovery of injured leaves.

——	Time of Fall of all the Leaflets.	Time of Fall of Primary Pulvinus.	Time of Complete Recovery of all the Leaflets.	Time of Complete Erection of Primary Pulvinus.
Leaflets only cut	60 sec.	94 sec.	600 sec.	360 sec.
	60 sec.	94 sec.	600 sec.	360 sec.
	60 sec.	80 sec.	420 sec.	880 sec.
Pinna cut	1 sec.	8 sec.	420 sec.	300 sec.
	2 sec.	1 sec.	780 sec.	660 sec.
	2 sec.	1 sec.	840 sec.	720 sec.
	3 sec.	4 sec.	420 sec.	300 sec.
	3 sec.	1 sec.	360 sec.	300 sec.
	3 sec.	1 sec.	360 sec.	300 sec.
	4 sec.	3 sec.	542 sec.	421 sec.
	4 sec.	2 sec.	400 sec.	303 sec.
	5 sec.	3 sec.	480 sec.	421 sec.

The first reading in the case of cut pinnæ is a little aberrant, and such readings were obtained amongst a large number of the typical ones; this one is included to show the danger of trusting to one or two experiments.

The figures show that when a leaflet is wounded the stimulus is first transmitted down the pinna concerned, then up the other pinnæ and down the main petiole; so that before the main pulvinus has had time to receive the shock all the leaflets have been affected. When the pinna is cut, however, the stimulus is much more violent and travels so rapidly down the main channel—the pulvinus—that it does not have time to side-track far up the other pinnæ before the primary pulvinus has been relaxed.

Heat.

The effects of heat come under two headings—first, heat shock, and second, heat injury. A shield must be used so that heat is not radiated to other parts of the plant. One made of a sheet of paper is the most convenient and is very effective.

If the heat be applied gently so that the leaves be not scorched a response similar to that given when the leaf is shaken is produced. It is local and is not transmitted. The temperature itself is not so much the deciding factor, but rather the change in temperature, and the rate at which it is applied. The sudden rising of the temperature by 5° C. is generally sufficient to produce a movement of the leaves. If the temperature be raised slowly no response is obtained until we reach about 60° C., when permanent injury may result. The temperature producing permanent injury varies with individual plants between about 60° and 70° C. This type of injury is as readily transmitted as an ordinary injury stimulus.

The Effect of Gases on Movement of *Mimosa pudica*.

It will be seen from the above data that there are two distinct types of response—(*a*) Simple shock response to stimuli which produce no permanent injury, and (*b*) injury response to stimuli which destroys or partly destroys the tissues. Under the first heading we have response to transmitted stimuli. *It is important therefore to distinguish between a direct response and a response to a transmitted stimulus when a leaf is exposed to a gas.* The experiments on wounding, heating, and shaking have shown that effects of this indirect stimulation may easily be confused with those of a direct one. When a plant is treated with gas part of the response may be due to the transmission of the stimulus from some more sensitive part and not really due to the direct action.

It was found that such was the case. When a jet of chloroform vapour was directed against a leaf it was found that the pulvini of the terminal leaflets were the most sensitive parts; next in order came the pulvini of the other leaflets, the secondary pulvini, and finally the primary pulvinus. By controlling the amount it was found possible to cause an injury stimulus in the terminal leaflets with a given concentration of chloroform while the same concentration had no effect on the primary pulvinus. The relatively feeble injury had not been sufficient to send the message to the base of the petiole. Thus it was found that the cautious introduction of ·25 cc. of chloroform per litre was sufficient to close the terminal leaflets in a typical specimen, whereas it took ·31 cc.

per litre to close them all. This treatment was found to have caused permanent injury to the leaf, but no change was apparent for some time in the primary pulvinus.

The experiments to be described were therefore carried out on the leaflets. One precaution had to be observed. The gas must be introduced gradually to preclude the possibility of shock stimulus. The plants were enclosed in a glass vessel so that the concentration could be controlled.

The effects of the following gases were investigated:—Chloroform, ether, sulphur dioxide, nitrous oxide, ammonia, and hydrogen sulphide. Of these, chloroform, ether, and nitrous oxide are anæsthetics, and sulphur dioxide, ammonia, and hydrogen sulphide plant poisons without anæsthetic properties.

(*a*) CHLOROFORM.—

The chloroform was introduced into the vessel covering the plant by means of fine atomizer. By means of a scale attached to the stem parallel with the petiole it was possible to measure the amount of movement due to curvature of the main pulvinus quickly and accurately; a further advantage was that the movement of the leaf was not hampered in any way as it would have been with any self-recording apparatus such as that employed by Bose. The observations on the movement of the leaflets did not require any such arrangement; the leaflets in an unstimulated normal leaf are placed flat and in the same plane, while when they are stimulated they are pressed together and therefore parallel with one another. In the experiments listed a large number of plants were tried, and though in each case the figures relative to only one plant have been quoted, they are typical of all the figures in each case.

The effect of sudden introduction of chloroform into the plant chamber.—The sudden introduction of the plant into an atmosphere containing ·25 cc. of chloroform per litre produced an immediate fall in the leaves. The time of recovery of this plant in ordinary air after a shock stimulus was 6 minutes. The leaves which had fallen when the plant was suddenly placed in the chloroformed air recovered to their full extent in 10 minutes. The petiole erected itself to the normal angle of 67·5° with the stem, and the leaflets, except the terminal ones, opened out so that they were in the same plane.

The effect of the gradual introduction of chloroform into the plant chamber.—The same quantity of chloroform (·25 cc. per litre) was gradually introduced into the plant chamber. The terminal leaflets of each pinna, always the most sensitive, slowly closed, but the rest remained open. This was taken as an indication that the effect of the chloroform was being felt by the plant and that anæsthetic action, if any, should be shown when the leaf is in such a state. A leaf was therefore struck while still in the vessel by means of a wire introduced through the wooden base of the stand. The characteristic shock movement was produced. The leaflets folded together and the primary pulvinus performed the usual curvature. Recovery started to take place immediately and the leaf assumed its normal position in 10 minutes as it had under normal conditions. Twice more this plant was subjected to shock stimulus without removing it from the bell jar, and in each case the rate of return was normal and the petiole assumed its normal angle of 67·5° with the stem.

Effect of prolonged exposure to dilute chloroform vapour.—The same plant was used in the last experiment and was left under the influence of the chloroform for 18 hours. At the end of this time it was found that its response still remained normal both in rate and amplitude.

Effect of larger amounts of chloroform on the amplitude of movement of the primary pulvinus.—A separate series of experiments was then carried out with a stronger concentration of chloroform. Instead of using a proportion which would injure the terminal leaflets only, sufficient was introduced to cause the closing of them all. In this case it was of no use to judge the amount of response by the response of the leaflets because they were already closed and could therefore show no further movement when stimulated. The observations were therefore made on the amplitude of the fall of the petiole. The amount of chloroform which when introduced slowly to prevent shock was found to cause closing of all the leaflets in a normal healthy plant was between ·30 and ·45 cc. per litre. The angle of the petiole with the stem was measured by the use of a scale attached to the stem. The following is the data of a typical example:—

Normal angle of petiole with stem .. 67.5°
Angle after shock .. .. .. 146°
Time of recovery to normal angle, 20 minutes.

·36 cc. of chloroform per litre was then slowly introduced. All the leaflets closed and the petiole slowly subsided until it reached 80 deg.

Angle of petiole after 21 minutes, 80° (21 minutes being the normal time of recovery).

This looked as if the action of the chloroform had been to cause a partial loss of sensitivity, but when the leaf was struck the fall was as rapid as before. The difference, however, was that it did not return to its normal angle of 67·5°. Permanent injury had taken place, and although the chloroform was removed the plant did not become normal again. The petioles remained at an angle of 80°, the leaflets remained closed and within a day or two withered and fell. Movement of the petiole was possible for a short time, but it was erratic and soon stopped altogether.

Recovery of leaves injured by chloroform.—There is obviously a point at which the leaves, though injured by exposure to an excessive amount of chloroform, will recover. A shorter exposure to the gas than that in the last experiment will produce injury to the leaf by closing the leaflets and causing a subsidence of the petiole to its injury equilibrium position. If at this point the chloroform is removed the plant will generally show a slow recovery. In such cases the sensitivity is not lost and at any time response to shock stimulus will take place. The full recovery takes place in from one to two days, depending on the amount of injury.

The following was the behaviour of a typical example:—

Amount of chloroform slowly introduced,	·35 cc. per litre.
Original angle of leaf with petiole ..	67·5°
Equilibrium injury angle	80°
Time of exposure to chloroform	25 minutes.
Period of complete recovery	30 hours.

Response of leaflets to the effect of chloroform introduced after they were closed.—Sufficient chloroform to affect the terminal leaflets injuriously was introduced after the leaves had been struck. The following is a typical case:—

Normal response.—Time of recovery of leaflets, 8 minutes.

Response under the influence of chloroform (·25 cc. per litre) introduced after the closing.—Time of recovery, 8 minutes. The terminal leaflets, as usual, did not recover. From this it may be seen that the effect of chloroform administered in an amount which if slightly increased would cause permanent injury produces no suspension of activity. The *Mimosa* leaf returns to its normal condition as if the reagent were not there. Even when permanent injury has been inflicted on the leaf, the response still takes place, though as death approaches it becomes feeble and erratic. The same feeble and erratic movements take place when the leaf is exposed to other unfavourable conditions such as heat, prolonged darkness, or drought, though in these cases the plant may recover if returned to normal conditions.

It is interesting to compare this erratic response with Thoday's findings[13] with regard to the want of correlation between the amount of oxygen absorbed and the amount of carbon dioxide produced by a plant under the prolonged influence of chloroform, and, further, with Osterhout's work,[14] on the effect of permeability. The evidence goes to show that up to a certain point chloroform exerts no disorganising effect but a stimulation of vital functions. This is not shown by the rate of response or the amplitude of the movements of the plant, but is shown only when the anæsthetic has been used in excess. How far can the effect on vital functions or respiration be correlated with this effect on the amount of response? It must certainly be reflected in the movements of the plant if from no other reason that a plant in an abnormal condition of health shows abnormal movement. Plants kept in the darkness or under conditions of drought, for instance, cease to respond.

(*b*) Ether.—

The behaviour of the sensitive plant under the influence of ether vapour was in all respects similar to that shown under the influence of chloroform.

(*c*) Ammonia.—

The sudden introduction of ammonia gas to the plant chamber produced a very rapid shock response, but when the amount was small a re-erection took place as rapidly as would have been the case in ordinary air. Larger amounts produced permanent injury. The leaflets shrivelled and the pulvinus lost its power of movement permanently.

(*d*) Hydrogen Sulphide.—

The effects of hydrogen sulphide were similar to those of ammonia.

(*e*) Formaldehyde.—

This gas produced a very marked injury effect when admitted to the plant chamber in large quantities. In low concentration no effect on the plant was apparent. When sufficient was admitted to cause a closing of the sensitive terminal leaflets, and the plant left under its influence, the leaves ceased to respond to stimulus. Removal of the formaldehyde resulted in no recovery. Defoliation occurred after about a day. The loss of power of response was therefore not of a temporary nature but the result of permanent injury.

(*f*) Benzene Vapour.—

The introduction of benzene vapour, whether slow or rapid, produced a very different effect from that produced by the gaseous poisons considered above. No excitatory fall took place, but a hardly perceptible bending of each pulvinus began, and the complete relaxation was produced in about an hour. The pulvini of the leaflets closed first, taking about 20 minutes to complete the process, and the primary pulvinus had fallen to its full extent in a few cases after 40 minutes, and in others somewhat over an hour. No recovery took place, and the pinnæ fell off the following day.

(*g*) Carbon Disulphide.—

The effects of carbon disulphide vapour were comparable with those of benzene vapour. The pulvini of the pinnæ completed their bending in about 20 minutes; the primary pulvinus taking an hour to complete curvature. The leaflets commenced falling off on the following day.

(*h*) Nitrous Oxide.—

This gas, an animal anæsthetic, had no effect on the movement of *Mimosa*. No excitatory fall was produced, and no difference in its rate of response could be detected. In a pure atmosphere of the gas a curvature of the pulvini took place; this, however, was not due to the nature of the gas. The same result was produced by surrounding a plant with a pure atmosphere of carbon dioxide, and recovery took place as soon as air was readmitted. The closing is analogous with that produced when the plant is placed under any unfavourable condition. In the case of treatment with nitrous oxide, the plant performs its normal movement if supplied with oxygen, but if the oxygen supply is cut off a slow closing of the leaflets takes place.

Three different types of behaviour are shown to the gases used in these experiments:—

(1) When chloroform, ether, carbon disulphide, or benzene gases are admitted in sufficient quantity a gradual bending of the pulvinus takes place.

(2) When large quantities of poisons which are not lipoid solvents, such as ammonia and formalin, are admitted, no gradual bending takes place although the tissues are killed.

(3) The action of nitrous oxide is an example of what happens when some essential factor, in this case oxygen, is excluded. It is therefore not of importance in considering the effect of anæsthetics on movement.

Controlled Movement of Pulvini.

As has already been pointed out, the power of movement is very readily influenced by slight variations of external conditions. *Desmodium gyrans,* the Telegraph Plant of India, is a plant the pulsation of whose leaflets is readily arrested by temperature or drought. The same applies to a lesser degree to *Biophytum sensitivum,* where the old leaves lose their power of movement. *Mimosa pudica*, however, is relatively tenacious of its response, although the young leaves and the terminal leaflets are more sensitive than the older ones. By comparison with other sensitive plants, it might therefore be expected that *Mimosa* might lose its power of response under any set of unfavourable circumstances which may or may not happen to have direct effect on the respiration.

Brown (*loc. cit.*) has shown that movement of the pulvinus of *Mimosa pudica* could be induced by the artificial changing of the osmotic pressure of the dead cells. In this experiment leaves were killed rapidly by heat, and most of the pulvini were found to have undergone curvature. A few, however, had been killed before movement had taken place and the artificial lowering of the osmotic pressure in them was accomplished by running them through various grades of alcohol and finally into xylol. The experiment showed that, in leaves killed before curvature had taken place, movement could be artificially induced, but that in those in which complete curvature was exhibited no such movement could be forced. In this experiment the change of osmotic pressure is artificial and not the same as the change occurring in the plant. Its importance, however, is that it demonstrates that the changing of osmotic pressure will bring about the movement.

A series of experiments was planned to bring about forced movements of *Mimosa* pulvini under the influence of different reagents. Some of the experements were based on Brown's experiment while others dealt with the subject from a somewhat different angle. It was found that if leaves attached to portions of the stem are placed in water immediately after their removal from the plant they re-erect themselves and are then in a condition where they may be treated with different reagents in solution. The amount of re-erection is rather greater than it would be under normal conditions and the rate of movement is greatly impeded, but as all the material is subject to these same conditions this is no drawback. If an erect petiole (attached to a piece of stem) be placed in a solution of ether it will bend slowly downwards, the rate of movement being dependent on the concentration of the solution. Some reagents did not produce this bending.

It was found impracticable to do experiments based on this observation in the case of the pulvini of the leaflets for the reason that when the leaflets had once folded together in the solution they adhered, and although treatment was of such a nature as to cause a movement of their pulvini, this movement was impeded and could not take place. Removal of the leaflets* on one side had the disadvantage of causing excessive mutilation and consequently unreliable response to subsequent stimuli.

Effect of Solutions of Various Enzyme Poisons and Lipoid Solvents on the Reaction of the Petioles of *Mimosa pudica*.

(*a*) Hydrogen Sulphide.—

This enzyme poison was found to produce no effect on the amplitude of the return angle of petioles of *Mimosa*. Portions of the stem with petioles attached were placed in water and the angle of recovery noted. On mechanical stimulation they exhibited response as usual of somewhat smaller amplitude than in the dry condition. The following are some typical figures:—

Table IV.—Response of pulvini after total immersion in water.

Specimen.	Angle of the Erect Petiole.	Angle after Mechanical Shock.	Amplitude of Movement.
A	33°	67·5°	34·5°
B	56°	112·5°	56·°5
C	40°	67·5°	27·5°
D	45°	80°	35°

When the material was transferred to a saturated solution of hydrogen sulphide it was found that the power of recovery was not abolished, but the power of response to mechanical shock had been lost. Thus a petiole having an angle of 33° when erect was placed in saturated hydrogen sulphide solution and lost its power of response to

* It is interesting to note that the folding together of the leaflets does not represent the total amount of movement of which the tertiary pulvini are capable. The mutual obstruction of the leaflets causes them to stop when an angle of 90 deg. has been reached. If the leaflets on one side are removed, the remaining ones fold over and make an angle of about 130 deg. with their original position. The *seta terminalis* should be removed to allow them to perform the full movement; if it is allowed to remain on the axis, it prevents the full movement of the terminal leaflet, which in turn obstructs the next one, and so on.

mechanical shock without, however, changing its angle. A petiole after being struck and then placed in the hydrogen sulphide solution slowly erected itself until it had returned to the normal angle which it had possessed before the original mechanical shock. It seemed as though the faculty of recovery was retained. The slow recovery, however, suggested that the lack of response to shock might be due to a similar slowing down and the shock of a more violent nature might produce a movement. This was found to be the case. A typical example was a petiole whose normal angle was 42 deg. and whose angle after mechanical shock was 90 deg. After it had assumed this latter angle it was immersed in hydrogen sulphide solution. In 30 minutes it had reassumed its normal angle. Attempts to make it respond to mechanical shock were unsuccessful, but when it was placed in hot water (80° C.) it subsided to the angle of 90°. By experiment it was found that the minimum temperature causing this movement, though varying a little, was 67·5° C. in the majority of cases. It might appear that this movement was due to the sudden coagulation of the protoplasm by the heat. Such, however, is not the case. The movement takes place in two distinct stages; first, the fall of the petiole through an arc of about 50°, and after this a sharp return through an angle of about 5°. The fall is to be interpreted as the excitatory fall, and the return to the coagulation of the protoplasm as the heat penetrates the tissues. From this it appears that the pulvinus is still capable of movement after immersion in hydrogen sulphide, but that a rigor mortis tends to retard it. A relaxed pulvinus recovers, but mechanical shock is not a sufficiently powerful stimulus to produce a fall.

(*b*) Formaldehyde.—

When pulvini were immersed in formalin solution for short periods of an hour or less the recovery was normal and heat stimulus resulted in a rapid curvature. Prolonged immersion destroyed all capacity for movement. Turgid pulvini were placed in a 10 per cent. solution of formalin, and left for eighteen hours. At the end of this period no relaxation had taken place. The material was then transferred to water and the temperature gradually raised. At 60° bubbles began to appear at the cut surface, but no movement took place. The temperature was gradually raised to 100°, and no movement took place.

(*c*) Sulphur Dioxide.—

Fallen pulvini immersed in a saturated solution of sulphur dioxide rapidly recovered. The angle of recovery was in all cases the same as it would have been with water, i.e., about 5° more than the normal angle in air. These results are comparable with those obtained with hydrogen sulphide.

(*d*) Ammonia.—

A number of sections of the stem each with a leaf attached were placed in a solution of ammonia (approximately 2 per cent. NH_3). For convenience the pinnæ were cut off. After 20 minutes the angle of the petioles with the stem was in each case the normal angle of an uninjured petiole. When portions of the stem with re-erected petioles were placed in the solution there was no fall although the tissues became blackened. When portions in which the pulvini were still relaxed were placed in the solution recovery was as rapid as when they were immersed in water. Such recovered pulvini showed rapid response to heat stimulus, but after prolonged immersion secondary changes (as indicated by the blackening of the tissues) took place and the power of movement was lost permanently.

(*e*) Ether.—

The behaviour of *Mimosa* pulvini immersed in ether is quite different from that exhibited when they are treated with ammonia or with hydrogen sulphide. The pulvini lose their power of recovery, and the amount of the loss for short periods is proportional to the amount of ether used.

It matters little whether relaxed or erect material is used. The rapidity of the action is the same. An erect pulvinus placed in ether solution gradually subsides, and a fallen one gradually erects itself if the concentration be suitable (see below, but a prolonged immersion even in dilute solution produces a complete bending. In order to obtain data as to the relative effect of different concentrations, therefore, it is necessary to choose a standard time at which to make the readings. The best is obviously the time which it would take for a petiole to re-erect itself when immersed in water. This varies from twenty to thirty minutes. The material was therefore immersed in the following concentration of ether for twenty-five minutes:—·5 per cent., 1·0 per cent., 1·5 per cent., 2·0 per cent., 2·5 per cent., and 3 per cent. by volume. The amount of recovery at the end of this time measured in terms of percentage of the angle of recovery of the same pulvini on the plants under normal conditions. For comparison the percentage recovery of petioles immersed in water was also made. The following table gives in summary form the results obtained:—

Table V.—Comparative erection of petioles after twenty-five minutes' immersion in water and various concentrations of ether.

——	Water.	Ether.					
	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
Concentration ..	..	·5	1·0	1·5	2·0	2·5	3·0
Percentage of normal amplitude	88·5	77·0	72·7	67·4	62·9	59·1	50·9

Each of the figures represents the average of forty sets of readings. Each set (in water and the various concentrations of ether) being made with material obtained from the same plant and carried out under similar laboratory conditions.

If the material is left in the ether solution for a longer time the petioles gradually bend down to their full extent. This is obviously connected with the lipoid solvent properties of ether which in varying concentration destroys the semi-permeability of the protoplasm at varying rates.

If a pulvinus that has been treated with a solution of ether and at the end of a short period, say, twenty minutes, is removed, it can be made to behave like a normal pulvinus whose maximum angle is equivalent to that which has been artificially produced. To take a particular example, a petiole was immersed in a 1·5 per cent. solution of ether for twenty-five minutes, then removed and washed. Its angle of recovery was 66·6 per cent. of the normal angle. By heat stimulation the petiole was found to subside to the original shock angle. It is interesting to compare the action of alcohol.

(*f*) ALCOHOL.—

Ethyl alcohol is a mild animal anæsthetic. Superficially its effects on *Mimosa* pulvini somewhat resemble those of ether. Brown has shown in the case of leaves killed by heat, but in which the leaflets have not had time to fold together before death, that bending can take place in alcohol. This is regarded as being due to the withdrawal of water by the alcohol with a consequent diminution of osmotic pressure, the direct result being the bending of the pulvini. Brown's experiments were repeated and verified, but owing to the difficulty (mentioned above) of the adhesion of the leaflets after they have once come together the primary pulvinus was used instead.

The material taken consisted as usual of portions of stems with pulvini attached. It was found that killing was not necessary.* Immersion in water for about twenty minutes after removal from the plant brought about their recovery. They were then run through varying grades of alcohol. The lower concentrations brought further curvature which was finally completed when the material was removed to absolute alcohol. So far the results were similar to those obtained with ether. The difference, however, lay in the fact that on transference to water the pulvini again became turgid and the petioles were re-erected, the time occupied by the process being twenty minutes. The difference in the action is marked and must be ascribed to the difference in lipoid solvent properties of the two reagents.

(*g*) CHLOROFORM.—

Turning again to chloroform we have a powerful anæsthetic and lipoid solvent. As is the case with ether, the treatment of pulvini with

* Seifriz[26] working on the effect of alcohol on the protoplasm of Elodea showed that a 10 per cent. solution is sufficient to kill 60 per cent. of the cells within half an hour, 80 per cent. within an hour, and 95 per cent. within two hours. A 3 per cent. solution will kill on an average more than half the number of cells in from four to six days. Using the plasmolytic method he found that the initial effect of ethyl alcohol is a pronounced increase in protoplasmic permeability followed by an increase in critical protoplasmic concentration and at least a partial decrease in permeability as a result of prolonged treatment. The ultimate effect of alcohol on Elodea protoplasm is coagulation.

chloroform results in an irreversible decrease in amplitude of the angle of response. A concentration of ·25 per cent. of chloroform was sufficient to cause a sensible curvature of a turgid pulvinus. Due to the insolubility of chloroform, however, it was not possible to get results exactly comparable with those obtained in the other experiments. The treatment of a turgid pulvinus with chloroform produced an irreversible depression. Treatment with the reagent of a pulvinus dehydrated with alcohol (and therefore fully depressed) and subsequent transference to water produced no re-erection.

(*h*) Benzene.—

Benzene is an extremely weak anæsthetic, but is a powerful lipoid solvent. Its insolubility in water (1·4 parts in 2,000) makes it impossible to measure the effects of varying concentration as was done in the case of ether, but when a pulvinus is treated with benzene it becomes incapable of erection. If a dehydrated pulvinus is immersed in benzene and after twenty minutes transferred to water no re-erection takes place. On the other hand, if a turgid pulvinus is placed in the reagent it gradually subsides, and this movement is irreversible.

Forced Movement of Pulvini after Treatment with Various Reagents.

As has been noted under the topic of the behaviour of pulvini treated with hydrogen sulphide solution, the forced movements produced by heat stimulus are peculiar. If a normal erect pulvinus be immersed in water and subjected to a gradual rise of temperature, a sudden bending takes place at about 67°, the temperature varying slightly with different individuals. The amplitude of the movement varies considerably with different pulvini according to their position on the stem. When full relaxation has taken place an immediate slight but very definite return movement takes place; this is sometimes as much as 10°, but is usually between 5° and 7°. The time occupied is about three seconds. This movement was interpreted as the initial response movement followed by a coagulation of the protoplasm, the latter action causing the return. As the contraction of the cells of the concave half of the pulvinus is responsible for the first bending, it seems reasonable to assume that the further contraction when protoplasm contracts will produce more contraction in the cells of the convex half than in those of the concave half, and the result will be a slight re-erection. Even by raising the temperature very slowly it was impossible to separate the two movements. The return movement always followed the excitatory fall immediately.

The behaviour of the pulvini when treated with a reagent causing coagulation was very irregular. When a number of turgid unstimulated pulvini were immersed in absolute alcohol, many of them gradually became relaxed and sank to a position which corresponded to that of the final return angle of pulvini which had been treated with hot water. This supports the theory advanced above that the return movement is due to coagulation. When these relaxed pulvini were removed and placed in water (at air temperature) they re-erected themselves and were to outward appearances similar to normal pulvini. They would not, however, respond to heat or any other stimulus. They remained erect and could be induced to bend only by dehydration in alcohol a second time. Those which when first immersed in alcohol remained unbent acted similarly. They would not respond to heat or other stimulus, even after re-immersion in water. It seemed that in some cases the bending due to dehydration took place either before coagulation was complete or that coagulation had not produced sufficient resistance to flexion to prevent the bending; in other cases coagulation had taken place rapidly enough to prevent the curvature. The close association of the temperature at which response takes place and that which causes coagulation of the protoplasm points to the importance of colloids in the response of *Mimosa*. Immersion of pulvini in solutions of hydrogen sulphide, ammonia, or formalin for short periods caused no alteration in the nature of their response to heat stimulus. Relaxed pulvini rapidly re-erected themselves in these solutions, and when erect pulvini were given similar treatment there was no loss of angle. Prolonged treatment with formalin or with ammonia, however, resulted in the loss of all power of movement. Secondary changes took place in the tissues, especially those treated with ammonia. These latter rapidly became yellow, and in the space of about half an hour were blackened. Immersion in hydrogen sulphide solution for hours had no effect at all on the subsequent movements.

Discussion.

Most of the work on the nature of the actual changes that take place in tissues treated with anæsthetics has been done with chloroform and ether. The effect on plant tissues of ether anæsthetics has also been investigated, but not to the same extent. The work may be divided into two headings—first, that dealing with effects on physiological behaviour, and second, that dealing with the effect of the substance on particular cell components.

1. *Effect on Physiological Behaviour.*—The early reputation of anæsthetics on plants was based on the action of chloroform and ether on *Mimosa pudica*. The statement has been made repeatedly that under the effects of such reagents this plant lost its power of response to shaking. If this were true it would be an important point from which to commence investigations on anæsthesia in plants. Unfortunately, however, as has been shown, treatment with these and other reagents producing anæsthesia in animals produces no such loss of power of response unless the amount used is so great as to cause a permanent injury. The early papers of Gayon who, in 1877, found complete inhibition of respiration of fruits by ether and chloroform; of Bernard who, in the following year, found that chloroform inhibited assimilation while respiration continued; of Schwarz, whose results published in 1881 showed a cessation of evolution of carbon

dioxide and of oxygen, and well as those of Bonnier and Mangin who, in 1886, confirmed the work of Bernard, were not available, but are cited by Bonns (*loc. cit.*) in his excellent résumé of the work on the effects of anæsthetics on respiration and photosynthesis.

Since this earlier work there have been numerous papers on the subject, of which the following are the principal ones:—Ewart[15] in 1898 found that chloroform inhibited carbon dioxide assimilation of *Elodea canadensis* without producing permanent injury. Morkowine[16] in 1899 worked on the effects of ether, alcohol, morphine hydrochlorate and solanin hydrochlorate on etiolated leaves and leaf buds of *Vicia faba* and *Lupinus luteus,* the green leaves of *Ficus elastica* and *Phylodendrum* sp., and on the embryos of sprouted wheat. He showed that anæsthetics increased the respiration both in etiolated and green plants. Two years later Morkowine[17] showed that anæsthetics had the effect of producing first a stimulation and later falling off in production of carbon dioxide. His previous work had demonstrated the initial increase. His later work showed that in dilute solution alkaloids (including those already mentioned) did not produce injury except after considerable exposure.

Annie A. Irving[18] found that small doses of chloroform increased respiration and that if the chloroform was withdrawn respiration reverted to its normal condition. Larger quantities first accelerated the respiration and then depressed it, while strong doses did not produce any acceleration, but depressed the amount of respiration from the time of application. Thoday's work (*loc. cit.*) on the effect of chloroform on the respiratory changes of leaves of the sunflower, garden nasturtium, cherry laurel, and other plants confirmed these results but further showed that in the period of acceleration the amount of production of carbon dioxide and the amount of absorption of oxygen remained co-ordinated, but when the production of carbon dioxide was diminished these two were no longer correlated.

Osterhout (*loc. cit.*) in 1913 determined the permeability of cells of *Laminaria* by measuring their conductance and found that there were two distinct effects under the influence of anæsthetics (chloroform, ether, chloral hydrate, and alcohol). First there was a decrease of permeability and then an increase. The decrease was reversible but the increase was not. As the typical action of anæsthetics is reversible, he assumed that the decrease in permeability was the typical anæsthetic action.

The work of A. R. C. Haas[19] in 1917 dealt with the connection between anæsthesia and respiration. The substances used were chloral hydrate, novocain, ether, caffeine, ethyl bromide (approximately saturated), formaldehye, chloroform, acetone and ethyl alcohol, dissolved in water. Like Osterhout he worked on *Laminaria.* Whenever the concentration of the anæsthetic was sufficiently strong to produce any effect the initial effect is always an increase of respiration which may remain approximately constant over long periods and then gradually decline, or the increased rate of respiration may fall very rapidly below the normal when the concentration of anæsthetics is too great. These results resemble those of Irving, and of Thoday.

It is important to note that E. Philip Smith[20] has recently pointed out that the alterations to permeability produced by anæsthetics include alterations to permeability to carbon dioxide, and that this factor may affect the apparent rate of respiration.

2. *Effect on Particular Cell Components.*—Burge[21] working on pigeons has demonstrated the fact that ether and chloroform have a marked destructive effect on the catalase of the blood, with a consequent decrease in oxidation. Appleman[22] has shown that, in the case of the potato, catalase activity shows a striking correlation with respiratory activity in the tubers, but that oxidase activity gives no indication of its intensity.

Ray[23] working on *Ulva lactuca* var. *latissima* obtained similar results to those of Haas (*loc. cit.*) but carried the investigation further, and showed that the same effect of chloroform could be produced on dead tissue killed by drying and subsequently treated with ferric sulphate and hydrogen peroxide. In a subsequent paper he showed that organic acids treated with hydrogen peroxide produce carbon dioxide at a rate that can be measured by the indicator method, and that in the case of acids containing a double bond this rate of production was influenced by the addition of an anæsthetic. The changes in rate are remarkably similar to those shown by the organism. Narcotics are well known to inhibit oxidation of inorganic substances such as oxalic acid. The importance of Ray's work lies in the demonstration of the nature of the action when respiration is influenced by the action of an anæsthetic.

The study of the effects of anæsthetics on tissues has resulted in the advancing of a number of theories of narcosis. The first of these was that of Overton[24]. Overton regarded the lipoid constituents of the plasma membrane as playing the important part, those substances which most readily destroy lipoids being most toxic.

Warburg's theory* is based on the action of narcotics on respiration, which has already been discussed. The retardation of oxidation of substances when treated with narcotics was found to run parallel with the value of the absorption constant, and such an action is therefore attributed to the decrease of absorption surface and a consequent decrease of oxidation.

Trude and Czapek have advanced theories dependent on the surface tension of the reagent, but the data on which their theories were founded have been found unreliable.

* For full critical discussion of theories of narcosis *see* Stiles and Jorgensen.[25]

The experiments of Seifriz[26] on the effects of alcohol and saponin lead him to conclude that lipoids play an important part in the constitution of the protoplasmic surface layer.

Kahho, whose work has been summarised by Stiles and Jorgensen and by Seifriz, in 1921 advanced the theory that permeability of protoplasm to substances is connected with their power to precipitate colloids, probably lipoids.

Lillie[27 28] has summarised his views, based largely on experimental work on the antagonism between salts and anæsthetics, and stressed the importance of the plasma membrane in the changes in permeability produced by various substances. A slight increase in permeability resulting from the action of an anæsthetic is attributed to the solvent action on the lipoids of this membrane. An increase on the amount of anæsthetic makes for increasing difficulty in the change of permeability owing to swelling of the lipoid particles; further increase results in such changes that permanent injury or death is the result. When the amount is such that it is difficult for an alteration in permeability to be effected, the resultant suspension of such action is anæsthesia.

From this outline of the work on anæsthetic action, it is evident that study of no one aspect of the subject is sufficient to afford an explanation of the reactions which together constitute the phenomenon. The experiments of Morkowine, Irving, Thoday, and Haas indicate the initial stimulation to carbon dioxide production, a character shared by typical poisons. Lillie's and Smith's observations show that this is connected with the increased permeability of the protoplasm, the permeability applying to carbon dioxide as well as to other substances. The work of Osterhout has established the fact that in the earlier stages the effect of anæsthetics on permeability is reversible.

A combination of a number of factors influencing respiration and permeability induces on animals the suspension of sensibility to external impressions. As the fundamental metabolism of plants and animals is in most respects very similar, it is to be expected that many of these reactions will be found common to both sets of organisms.

The nature of the movement of plants, however, does not show this close similarity with the nature of movement in animals, and the experimental data presented in this paper shows that in the case of *Mimosa pudica*, the classical example of a plant showing a marked power of movement, no suspension of irritability occurs.

The effect of anæsthetics on processes of respiration, transpiration &c., is dependent on the fundamental effect on permeability, which in turn rests on the effect on the plasma membrane. The movement of *Mimosa pudica* is due to contraction of the protoplasm. It does not necessarily follow, therefore, that the initial changes of increased permeability followed by decreased permeability on the membrane will be paralleled by increased power of movement and then a decreased power.

The term anæsthesia implies a suspension of sensitivity, and in this respect therefore cannot be applied to the result of the action of anæsthetics on *Mimosa pudica.*

The evidence for this statement is as follows:—

(1) When the living plant is subjected to the action of chloroform or ether no suspension of sensitivity occurs.

(2) The power of movement is lost only when the plant is permanently injured.

(3) Gaseous poisons such as hydrogen sulphide, formalin, and ammonia have the same effect on the living plant as have ether and chloroform; in low concentrations response was normal, and the only suspension of activity takes place when permanent injury has been inflicted.

(4) Temporary suspension of activity can only be produced by placing the plant under conditions unfavourable to its normal metabolism. Such a suspension may be produced by absence of light or by depriving the plant of oxygen. The effect of nitrous oxide in producing a temporary suspension can only be produced by the withdrawal of the oxygen at the same time; carbon dioxide has the same effect under the same conditions.

(5) When the pulvini are immersed in ether solution the rate of bending is proportional to the concentration of the solution. Lipoid solvents produce a similar curvature, and at any period the pulvinus is capable of normal response to heat stimulus. The destructive action does not affect the power of movement until the loss of permeability is complete, when further curvature is obviously impossible. There is no suspension of irritability.

(6) Enzyme poisons such as sulphur dioxide, ammonia, and formalin destroy the capacity for movement of pulvini immersed in them only after prolonged treatment. The movement, though dependent on the general condition of health of the cells, is therefore not directly connected with the enzyme destruction.

(7) Alcohol, a mild animal anæsthetic, prevents movement by coagulating the protoplasm. This is not a suspension of sensitivity, the action being irreversible.

The effect of poisonous gases on sufficient quantity to cause a permanent injury to the living plant results in curvature of its pulvini. This curvature takes place when the pulvini are injured by any other method, or when they die from natural causes. Though in outward appearance similar to the movement caused by lipoid solvents it is in reality quite different, not being caused by a loss of permeability. It is in connection with this point that the study of the effect of solution of enzyme poisons on the immersed pulvini was of special importance. A pulvinus which through injury has lost its normal capacity for movement reveals the true nature of its injury when subject to the gentle forcing treatment of this method.*

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SUMMARY.

1. Two types of response are shown by *Mimosa pudica*—shock response and injury response. Injury may result in injury response in part of a leaf while other parts to which the stimulus has been transmitted will show shock response only. Confusion between these types must be avoided in studying the effects of a reagent.

2. Plants treated with chloroform, ether, ammonia, or formalin gases showed no suspension of power of response. The capacity for movement was only lost when plants were permanently injured.

3. The sudden introduction of these gases into the plant chamber caused a shock response, but recovery was as rapid as in air.

4. Carbon disulphide and benzene vapours caused a slow subsidence even in low concentrations. This same loss of angle was produced by prolonged exposure to large amounts of chloroform or ether, but was not shown by plants exposed to the vapour of poisonous gases which were not lipoid solvents.

5. Nitrous oxide is without effect on movement of *Mimosa* when oxygen is supplied to the plant. When pure nitrous oxide surrounds the plant movement ceases temporarily, but the same result is obtained by the exclusion of oxygen.

6. When pulvini are immersed in solutions of enzyme poisons their recovery takes place as rapidly as if they were immersed in water only.

7. When pulvini are immersed in solutions of chloroform or ether, or in benzene they gradually curve. At any time during this curvature they are capable of response to heat stimulus, thus showing that the power of movement is not suspended.

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* As illustration of this principle the following case may be cited:—*Pseudococcus virgatus* Ckll., a sucking insect attacking a wide range of plants, sometimes attacks the leaves of *Mimosa pudica*, rendering their pulvini irresponsive to stimulus. Immersion of the leaves in water for about twenty minutes restores the power of response.

8. The action of alcohol, a mild animal anæsthetic, is complicated by the fact that the protoplasm is coagulated.

9. In the course of the experiments it was found that if pulvini are heated in water, a rapid bending takes place at about 67°, the exact temperature varying with different plants. As soon as this curvature has been completed a rapid return movement takes place through an angle of 5-10 deg. This latter movement is due to the coagulation of protoplasm and its intimate association with the response movement points to the importance of colloids in the movement of *Mimosa.*

10. The effect of ether and chloroform on the movement of *Mimosa pudica* is that of ordinary lipoid solvents, and is due to the effect on permeability. The effect of enzyme poisons in solution is to produce no change in the power of movement of pulvini immersed in them, so it is assumed that anæsthetics in their role of enzyme poisons do not affect movement directly.

11. The term anæsthesia in so far as it implies a suspension of sensibility to external impressions cannot be applied to the effect of ether and chloroform on *Mimosa pudica.*

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Geological Features of the Mandated Territory of New Guinea.

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INTRODUCTION.

In 1923 the Rev. C. H. Massey read an interesting paper on the Physiography of this Territory before the Royal Society of Queensland. His notes on the volcanoes are valuable as being compiled from personal observation, but his supposition that an old Australian continental mass included islands as remote as Fiji, Tonga, and Kermadec at the one time is open to grave doubt.

The late Mr. E. R. Stanley's report on the Mandated Territory and adjoining islands is undoubtedly the best compendium we have of the geology of the Mandated Territory. Much of Stanley's discussion of trend lines and of the various mountain areas and their virgation must be regarded as theoretical and open to correction and modification as research proceeds, but the map submitted by Stanley is a magnificent basis for future research.

I do not purpose to enter at length into theoretical discussions, but desire to record a few of the essential facts known about the Mandated Territory and adjacent islands and to show what conclusions can be safely drawn from these facts.

GEOLOGY.

The mainland portion of the Mandated Territory consists mainly of continental rocks, embracing schists, slates, quartzites, greywackes, granites, diorites, gabbros and similar rocks of plutonic and metamorphic nature. The schists are largely coarse-grained mica schists and phyllites comparable to those one meets with in the Pre-Cambrian regions of the Northern Territory, in the Etheridge and Cloncurry districts of North Queensland, and in the D'Aguilar Range north of Mt. Mee. The coarse schists are certainly Palæozoic and may be pre-Cambrian.

In addition to this oldest series of metamorphic rocks, there is another series of highly crushed and metamorphosed sediments which have not been regionally metamorphosed to the same extent. This series occurs mainly in the coastal strip, but remains of it are also found infaulted in places amongst rocks of the older series. Granites, diorites, and serpentines intrude the series, and in the neighbourhood of the intrusions intense contact metamorphism occurs with the formation of marbles, cherts, slates and sericite schist, but more remote from the intrusions the rocks, though intensely folded, faulted and crushed, and though traversed by calcite and quartz veins, have not been wholly recrystallised and range in character from slates to somewhat altered shales. These rocks were usually assigned by Mr. Stanley to the Astrolabe-Kemp-Welch series, which he regarded as probably pre-Cambrian, but I am of opinion that the rocks of many of the areas included in this series, as for instance the Nobinob series N.W. of Madang, are altered early Tertiary or Cretaceous sediments. Professor David informs me that *Globigerina* occurs in some of Stanley's rocks of this kind, which confirms a Cretaceous or post-Cretaceous age for them. Evidently to correctly assign the Astrolabe-Kemp-Welch series of rocks to their proper horizons careful microscopic research is essential.

Absolutely fringing the coast we have a belt of Tertiary unmetamorphosed sediments ranging in age from Miocene to Recent. The belt is usually narrow, but in places it widens and extends a considerable distance inland, as at the mouths of the Sepik and Ramu Rivers. Sometimes these middle and late Tertiary rocks are highly folded and disturbed, as at Potsdamhafen and south of the Naru River on the northern slopes of the Finisterre Range. In other places there has been less disturbance and it is in such localities that a search for oil can be profitably pursued. Between the Naru River and Madang the late Tertiary series ranging from Miocene to Pleistocene attain a thickness of over 8,000 feet.

New Ireland and New Hanover have cores of continental rocks, both plutonic and metamorphic. New Britain itself, far from being wholly volcanic, has areas of granite and schist as well as areas of Tertiary rocks.

FAULTING.

The physiography of New Guinea points to tremendous trough and block faulting throughout the Tertiary period. Rift valleys and horsts exist both on the land and beneath the sea. Some of the earliest troughs have been heavily sedimented, folded, re-elevated into ranges, and intruded by plutonic rocks in early Tertiary times as, for instance, the country north of Astrolabe Bay between the Ramu River and the coast.

Faulting no doubt also accounts for New Britain and other areas being divided up into metamorphic, Tertiary, and purely volcanic segments. The late Tertiary fissures strike chiefly N.W. or N.N.W. Volcanic effusions have broken through along the fault cracks, thus giving the volcanoes and volcanic islands a N.W. alignment. The greatest and most persistently active volcanoes occur principally along N.N.W. faults in troughs at present undergoing heavy sedimentation or loading by the action of growing coral. Thus the perpetually active craters of Bam and Vulcan or Manam Island owe their persistent activity to the loading of the sea with sediments carried down by the great Sepik River. The volcanoes of the Solomons are kept alive by the pressure of coral accumulation.

Stanley has mentioned several probable faults of great magnitude on the mainland of New Guinea. I can personally confirm the existence of the great Ramu River fault, and state that it continues in a N.W. direction across the Sepik River to the north coast at a point two miles west of Kaup near the Mom Headland.

CONCLUSIONS.

Mr. Massey contended that New Britain is a subsidence area and New Ireland an area of uplift. I am quite in agreement with Mr. Massey in his general argument that the islands and deeps contain numerous subsidence areas, but I should personally consider New Britain composite, consisting of the horst (probably uplifted) in Gazelle Peninsula, a Pleistocene uplifted portion and volcanic portions which have probably subsided. These segments are separated by faults striking N.W. The general contention put forward by Mr. Massey that the islands of New Guinea form the remains of a broken-up continent I agree with. My conclusion is that up to the Cretaceous period New Guinea, the surrounding islands, the Coral Sea and possibly New Caledonia formed a continental mass continuous with North Queensland and Central Australia.

In the Cretaceous commenced the breaking up, which became more violent in the early Tertiary. Many trough blocks were heavily sedimented and intensely crushed, folded, intruded and metamorphosed, being subjected to intense igneous action as well as squeezed between the uplifted segments on either side. Thus we get areas of metamorphosed Cretaceous rock among the schists of the Bismarck Range, Bewani Range and other Palæozoic, if not pre-Cambrian, areas (*vide* Bergman, Stanley, and other explorers), and areas of metamorphosed early Tertiary rock. These processes still continue. Miocene and Pliocene sediments are highly disturbed on many parts of the coast, and in submerged areas where sedimentation is still going on upon such rocks, coupled with the injection of igneous intrusions from the igneous foci, the later Tertiary rocks are being metamorphosed at the present day.

The new ranges formed in New Guinea out of Tertiary sediments have been moulded on the fault blocks. Hence they have a N.W. direction chiefly. That is the general strike direction of newer sediments on the mainland where the Ramu fault and coastal fault east of the Finisterre Range control the subsequent folding.

Trend Lines and Folding.

Much has been said by Messrs. Stanley and Massey on this subject. I will only add that a glance at any map of New Guinea showing the ranges will convince anyone acquainted with the relations between geological structure and topographical structure that the original trend lines of New Guinea were nearly E.W., or from W.N.W. to E.S.E. The main axis of New Guinea, namely the Victor Emmanuel Range, the axis of the Bewani Mountains and of the Torricelli Range in the Mandated, Territory conform to this direction. They are all metamorphic, composed mainly of schists, phyllites, granulites, quartzites, greywackes and plutonic intrusions, and it is the differential erosion of alternately harder and softer formations that form the ranges and gorges. The main axes are largely igneous.

Reference to my paper issued by this Society on 9th November, 1922 ("Some Geographical Features of Northern Australia") will show that the W.N.W. trends also hold for the oldest formations of Northern Australia, and are typical of Archean trend lines throughout tropical regions of the southern hemisphere, in the same manner as Suess has shown the E.N.E. trends typical of all the oldest rocks in the tropical regions of the northern hemisphere.

The newer trend lines are the result of faulting and the moulding of later sediments laid down in subsidence areas on the horsts and on the original continental shores. Some therefore adhere to and others deviate from the original trend direction. In Northern Australia, as in New Guinea, faulting has been largely on N.N.W. directions.

The contention that the Coral Sea has been part of the old Australian continent is supported by the fact that so many islands along the coast of North Queensland are granitic and metamorphic, as, for instance, Hinchinbrook Island, the Palm Islands, Magnetic Island, and Holbourne Island, as well as smaller rocks in the Great Barrier Reef.

As subsidiary evidence I might refer again to the fact that the metamorphic gold and copper-bearing regions of Northern New Caledonia are almost an exact replica of the rocks we get in part of the D'Aguilar Range, in Curtis and Facing Islands east of Gladstone, and other places where the "Brisbane Schists" are intensely metamorphic, while the Tertiary and Serpentine of New Caledonia are petrologically as well as in the earth processes passed through remarkably like parts of New Guinea.

I should imagine that the connection between New Caledonia and Southern Queensland would have existed in early Palæozoic times when perhaps a South Pacific island continent south-east of Australia was in existence, while the connection between New Guinea and New Caledonia was essentially Mesozoic. Botanical evidence such as the abundance of Casuarineæ, Acacias and Melaleucas in New Caledonia seems to point to connection with Australia lasting longer than connection with New Guinea.

While New Guinea is very analogous geologically in many respects to Borneo and the Philippines in possessing a continental core, it differs, as far as one can judge on existing knowledge, in having a far greater development of basic plutonic rocks in the absence of tin-bearing granites. Borneo and Sumatra are lithologically closer akin to the Northern Territory than to New Guinea. Java, composed as far as I know wholly of Tertiary and volcanic rocks, may be moulded on an Archæan structure now subsided, thus accounting for its E.W. trend.

I refer the readers of this paper to Mr. Stanley's excellent maps of British New Guinea and of the Mandated Territory for detailed geological information. My object in this note is to place before the Society some facts about New Guinea that help to elucidate Australian geology and some lines of thought that are not conventional nor in keeping with present theories about the various Australian arcs of folding and their virgation in New Guinea.

Contribution to the Queensland Flora, No. 3.

By C. T. White, Government Botanist, and W. D. Francis, Assistant Government Botanist.

Plates I.–X.

(*Read before the Royal Society of Queensland, 28th September, 1925.*)

The present paper contains descriptions and figures of a number of new species of flowering plants which have come to our notice since the previous contribution of this series was presented for publication (Proc. Roy. Soc. Qld., vol. xxxv., pp. 63-84, 1924). Mostly the specimens have come under observation in the course of examination of collections received at the Queensland Herbarium for identification.

In addition to these plants entirely new to our knowledge, descriptions of previously unknown parts, such as flowers or fruit, of already known species which have come under notice, are included. The opportunity is also taken to publish notes, comments on descriptions, and interesting locality records of native plants and new records of Australian and alien plants which have been found or have recently appeared in the State.

Order PITTOSPORACEÆ.

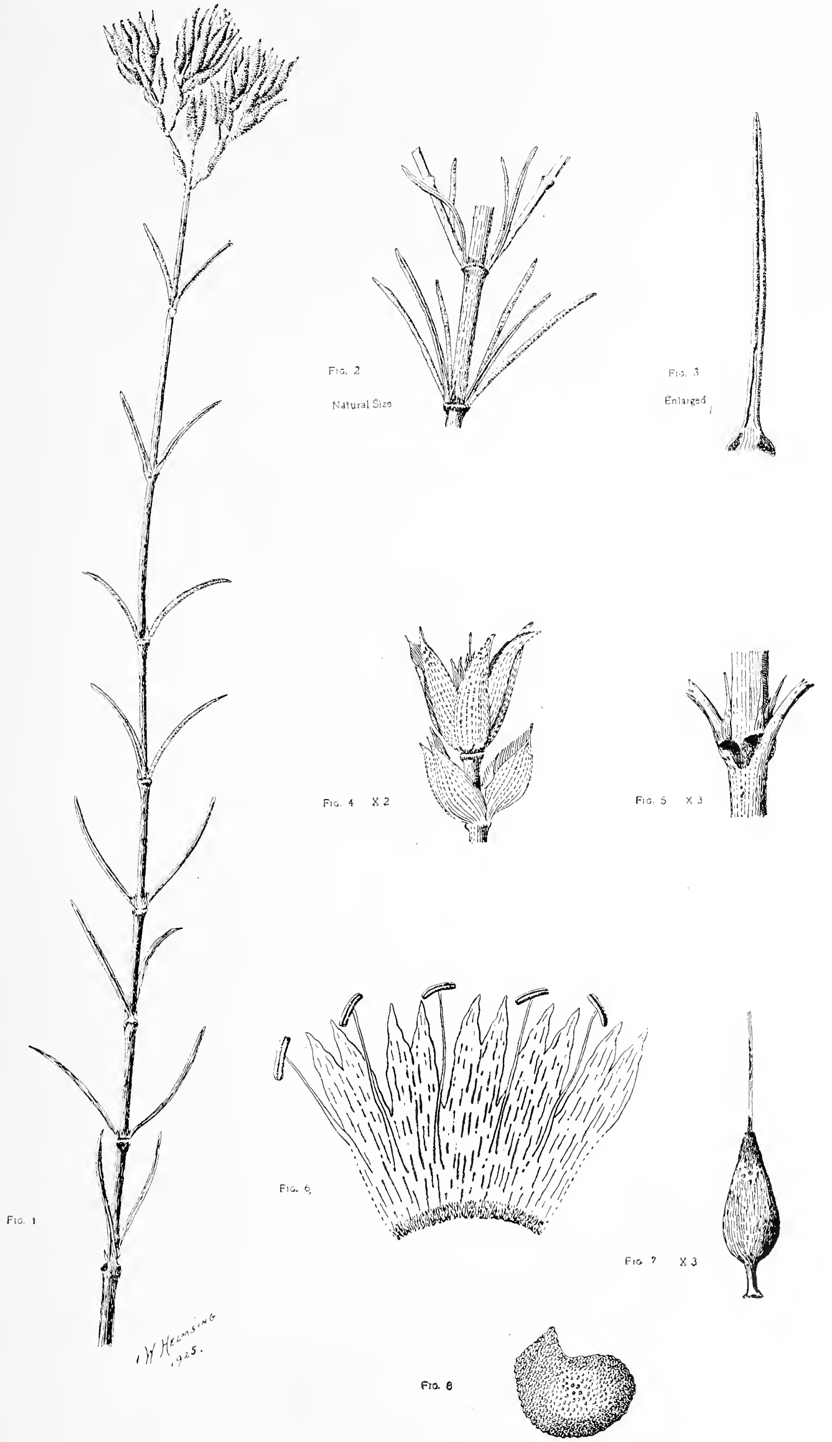
Pittosporum venulosum F. v. M. Flowers previously unknown. Inflorescence terminating the branchlets, umbelliform, much shorter than the leaves ; rhachis and pedicels densely ferruginous pubescent ; main rhachis extremely short or rarely attaining 1·3 cm. ; pedicels 6-10 mm. long. Calyx densely ferruginous pubescent outside, glabrous inside, campanulate, about 4 mm. long, divided almost to the base into 5 ovate, obtuse lobes. Petals 5, glabrous, strongly imbricate, oblong or linear, 8-10 mm. long and less than 2 mm. broad. Stamens glabrous ; filaments terete or slightly flattened, about 2 mm. long ; anthers lanceolate, about 2 mm. long. Ovary densely ferruginous pubescent, ovate ; style glabrous, about 2 mm. long ; stigma glabrous, capitate, obscurely 4-lobed.

Described from specimens collected from a small tree about 20 cm. in stem diameter at about 3,000 feet altitude on Eungella Range, North Queensland, by W. D. Francis in October, 1922.

Order CARYOPHYLLACEÆ.

Polycarpæa glabra (new species). (Plate I.)

Herba perennis glabra ca. 30 cm. alta ; caulibus subligneis ; foliis oppositis (nonnunquam cum 1-4 foliis parvioribus e nodo uno), marginibus revolutis ; stipulis scariosis integris et acutis vel crebro in setis divisis ;



Polycarpæa glabra (new species).

1 and 2 about natural size; 3, leaf showing underside, magnified; 4, flower showing subtending bracts, magnified; 5, node showing stipules, × 3; 6, tube of united petals laid open showing stamens, × 5; 7, ovary × 5; 8 seed × 35.

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inflorescentiis cymosis 1·3–2·5 cm. dia.; bracteis scariosis ovatis concavis acutis ad basem subauriculatis; pedicellis 2 mm. longis vel sæpe obsoletis; sepalis albis lanceolatis acutis; petalis cum staminibus in tubo conjunctis, partibus liberis 2 mm. longis alte trifidis; filamentis petalorum partem libera aequantibus; ovario stipitato fusiformi vel subcylindrato, stylo gracili.

Stems somewhat woody and rigid, attaining about 30 cm. or more in height and 2 mm. in diameter. All parts glabrous. Leaves opposite, occasionally with 1-4 smaller additional ones arising from the same node, margins strongly revolute giving the leaf a terete appearance, apex acute, 1·3–2·5 cm. long. Stipules scarious, entire and acute or more frequently divided into setae, not exceeding 2 mm. in length. Inflorescence composed of corymbose cymes, 1·3–2·5 cm. in breadth. Bracts subtending the pedicels and branches of the inflorescence scarious, ovate and stem-clasping at base, acute, 2-4 mm. long. Pedicels attaining 2 mm. in length or obsolete. Sepals white and scarious, the midrib not brightly coloured, lanceolate, acute, attaining 6 mm. in length. Petals united with the stamens in a tube nearly 2 mm. long, their free parts 2 mm. long and deeply bifid at apex. Filaments about as long as free part of petals. Anthers ·7 mm. long. Ovary on a stipes 1 mm. long, fusiform or subcylindrical, 3 mm. long; style slender, nearly 3 mm. long.

Locality: Dugald Silver-Lead Lodes, Cloncurry District, J. B. Miller, 16th April, 1924.

This new species appears to be allied to *P. longiflora* F. v. M. and *P. Burtoni* Bail. From the latter it is distinguished by its short staminal tube and white flowers, from the former by its stipitate and subcylindrical ovary, smaller inflorescence and glabrous character. Mr. J. B. Miller, who collected the specimens, states that this plant and a grass, *Eriachne mucronata*, constitute the only vegetation growing on the lodes and that stock do not touch them. It is interesting to note that Professor Skertchly has stated that *Polycarpæa spirostyles*, which he called the Copper Plant, is a useful indication of copper lodes in North Queensland, as it was noticed by local residents that this species is always associated with these lodes (*see* Pamphlet entitled "The Copper Plant," accompanying S. B. J. Skertchly's "Report on the Mines of Watsonville.")

ORDER RUTACEÆ.

Melicope stipitata (new species). (Plate II.)

Arbor parva; ramulis foliisque glabris; foliis oppositis petiolatis unifoliolatis; foliolo sessili, lamina oblanceolata vel anguste elliptica obtuse acuminata basi angustata subtus nervis prominulis; paniculis terminalibus; pedicellis tenuis 3-6 mm. longis; calyce alte 4-lobato, lobis ovato-triangularibus, marginibus ciliolatis; petalis lanceolatis extus parce pubescentibus; filamentis et intus et ad margines inferne tomentosis, antheris ovatis; ovario longe stipitato, carpellis 4 pubescentibus vel strigosis; coccis maturis 8-10 mm. longis, valvis transverse rugulosis.

Described by the collector as a small tree of 12 metres in height with sparse foliage, slate-coloured bark and white flowers. All parts except flowers glabrous. Branchlets terete. Leaves opposite, unifoliolate. Petiole

4-10 mm. long. Blade of leaflet oblanceolate or narrowly elliptical, narrowed at base, bluntly acuminate at apex, the midrib and 7-10 lateral nerves on each side of it prominent on the underside, the lateral nerves scarcely visible on the upper side, 9-13 cm. long, about three times as long as broad. Inflorescence fragmentary in our specimens, cymes arranged in the form of a broad panicle. Pedicels slender, 3-6 mm. long. Calyx divided to base into 4 ovate-triangular lobes with ciliate margins, the lobes ·5 mm. long. Petals 4, sparingly pubescent outside, densely hoary pubescent inside, lanceolate, 5 mm. long. Stamens 8. Filaments flattened and tomentose on the margins and inner side in the lower part, slender, tapering and glabrous in upper part, 4 mm. long. Anthers ovate, dorsifixed, ·6 mm. long. Ovary on a conspicuous glabrous stipes 1·2 mm. long, the 4 carpels pubescent or strigose, separated and almost distinct from the base; style 1 mm. long. Cocci 4, shortly and broadly stipitate, 8-10 mm. long, 8-10 mm. wide in the upper part; valves opening along the upper and inner edge, prominently transversely wrinkled.

Locality: Glenallyn, Malanda, North Queensland, H. C. Hayes.

This new species is distinguished from *M. Fareana* F. v. M. and *M. melanophloia* C. T. White, the only other unifoliolate species of the genus in Queensland, by its much shorter petioles and stipitate ovary. Another species of the genus, *M. neurococca* Benth. (*Bouchardatia neurococca* H. Baill.) has a stipitate ovary and it may be allied to *M. stipitata*. Unfortunately the material of the latter at hand is not sufficiently preserved to enable the number of ovules or seeds in each carpel to be determined.

Melicope glabriflora White and Francis, Botany Bulletin No. 22, Department of Agriculture, Brisbane, p. 3. An examination of a recent collection of plants revealed specimens which are evidently intermediate between *Melicope glabriflora* and *M. Broadbentiana* Bail. These specimens show that *M. glabriflora* is probably only a form of *M. Broadbentiana* with aberrant flowers, and therefore the former name should lapse. A comparison of the floral structure of the specimens of *M. Broadbentiana* and those of the synonymous *M. glabriflora* shows that the flowers in this species are to a certain extent dimorphic as the filaments are long and pubescent in the original type specimens and short and glabrous in the specimens originally described under *M. glabriflora*. This dimorphism is probably connected with sexual differences.

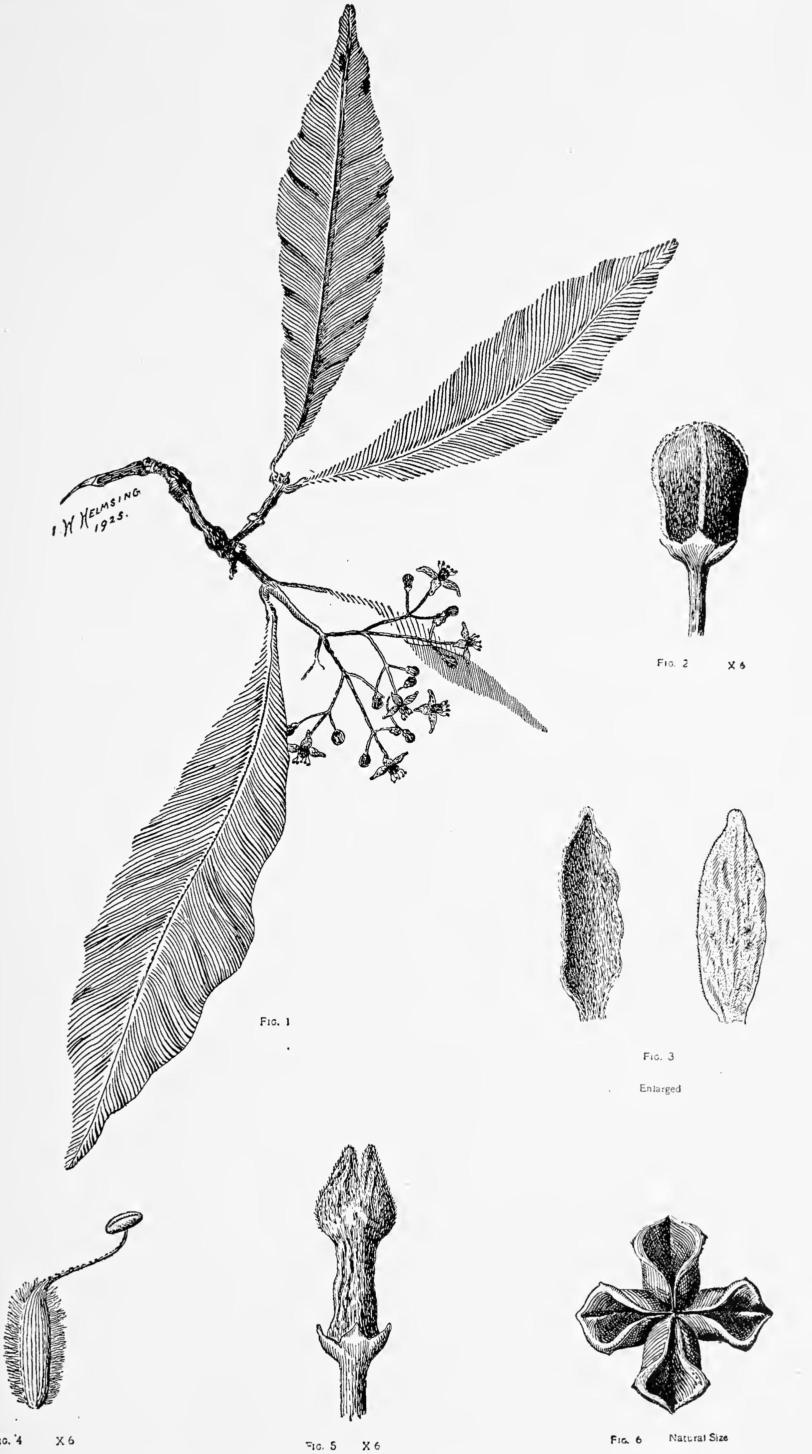
Order MELIACEÆ.

Owenia reticulata F. v. M. Only recorded previously from the Islands of the Gulf of Carpentaria. Specimens from Van Rook in the Southern part of Cape York Peninsula, received through the courtesy of the late Chief Justice McCawley, establish a record of its occurrence on the mainland.

Order CELASTRACEÆ.

Elæodendron microcarpum (new species). (Plate III.)

Arbor mediocris, ramulis juvenilibus gracilis quadrangularibus; foliis petiolatis, lamina elliptica integra ad basem angustata ad apicem breviter et obtuse acuminata; cymis dichotomis axillaribus vel lateralibus



Melicope stipitata (new species), about one-half natural size. Fig. 2, bud × 6; fig. 3, petals enlarged; fig. 4, stamen × 6; fig. 5, stipitate ovary × 6; fig. 6, cocci after dehiscence.

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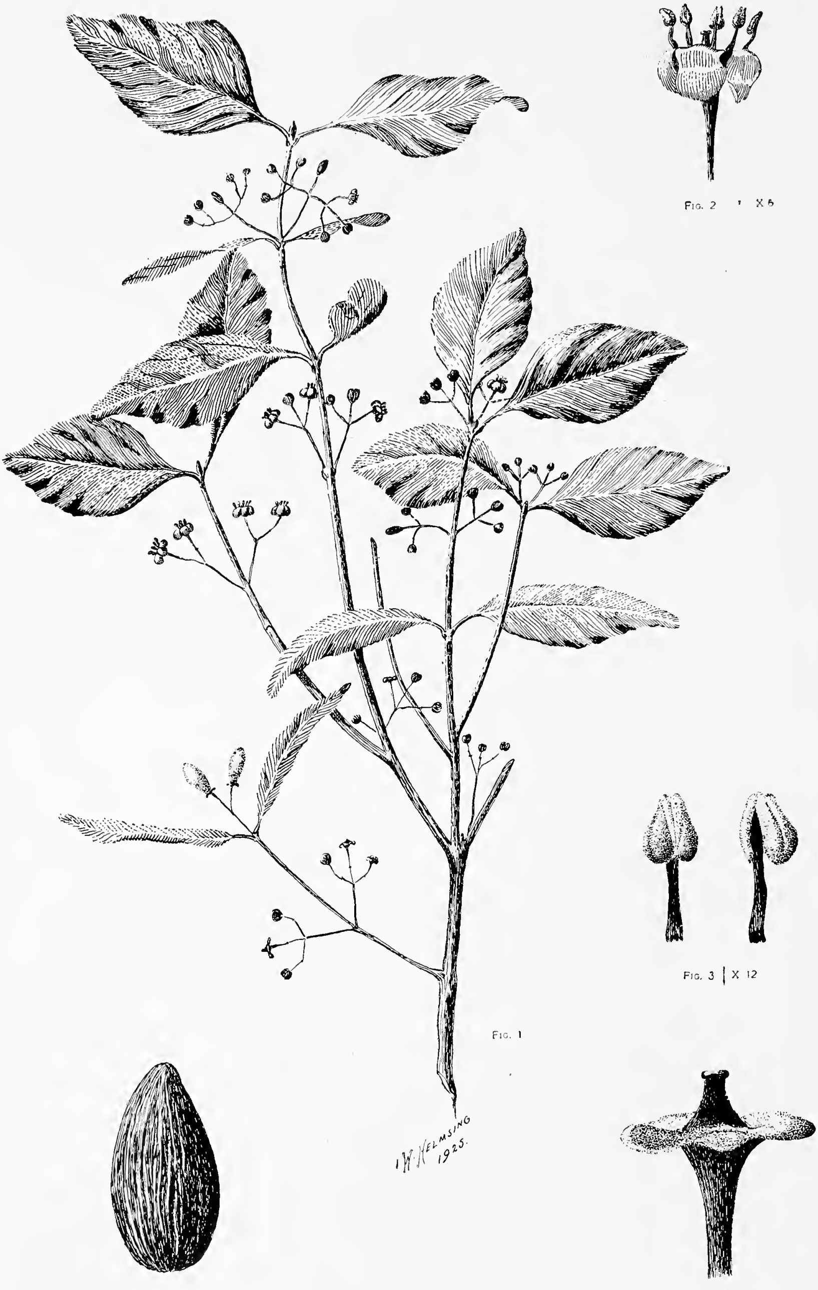

FIG. 1
FIG. 2 × 6
FIG. 3 × 12
FIG. 4 × 12
FIG. 5 × 6

Elæodendron microcarpum (new species). 1, about one-half natural size ; 2, flower × 6 ; 3, stamens × 12 ; 4, flower with petals and stamens removed × 12 ; 5, seed × 6.

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sæpe oppositis; pedunculis tenuis; floribus 5-meris; calyce concavo obscure 5-lobato; petalis late ovatis obtusis reflexis vix 2 mm. longis; staminibus ca. 2-3 petalorum longitudinis, antheris ovatis; disco lato plano solitari nigro ovato.

A small glabrous tree. Young branchlets slender and quadrangular. Petioles 2-4 mm. long. Leaves opposite, elliptical, entire, narrowed at the base, obtuse or shortly and obtusely acuminate at the apex, midrib, lateral nerves (about 5 or 6 on each side of the midrib) and a few reticulate veins visible above and more conspicuous on the underside, 4·5–5·7 cm. long, about twice as long as broad. Cymes dichotomous, axillary or lateral, often arranged in opposite pairs on the branchlets between the leaves; peduncles slender, 4-8 mm. long, pedicels 3-4 mm. long. Flowers 5-merous. Calyx concave, about 2 mm. in diameter, its rim with 5 broad obscure, rounded lobes. Petals broadly ovate, obtuse, reflexed, less than 2 mm. long. Stamens about $\frac{2}{3}$ the length of the petals, the ovate anthers about half the length of the filaments. Disk broad, flat and obscurely lobed. Ovary immersed in the disk, surmounted by an ovoid, obtuse style. Fruit ovoid, more or less oblique, 5-6 mm. long, the scar of the style (?) unilateral; pericarp fairly dry, coriaceous, flesh-coloured or light brown; seed solitary, black, ovate, 4 mm. long.

Locality: Mt. Perry, Jas. Keys (type); Imbil, W. R. Petrie.

This species is allied to *Elæodendron australe* Vent. from which it is distinguished by its 5-merous, smaller flowers, dry, smaller fruit and smaller and thinner leaves.

Order AMPELIDEÆ.

Vitis acris F. v. M. Frag. Fruit (previously unknown) white, depressed-globular, about $\frac{1}{2}$-in. (1·3 cm.) in diameter; seeds light brown or straw-coloured, about 3 lines (6 mm.) long and 2 lines (4 mm.) broad. Described from specimens collected near Toowoomba by Dr. T. A. Price, January 1924.

Order LEGUMINOSÆ.

Mirbelia speciosa. Sieb. For some time past we have had under review a large form of *M. speciosa* growing at Crow's Nest, and recently Mr. L. Brass collected a fine series of specimens of this form in that district. It differs from the type in being larger in all its parts, the leaves measuring in some cases nearly 5 cm. in length, (1·2–1·8 cm. in type). The flowers are slightly larger and the pod measures 17 mm. (8-10 mm. in the type) long on a stipes of about 4 mm. We had at first thought to give it a distinct varietal name, but specimens from the Queensland–New South Wales b rder seem to be a connecting link between it and the more typical Port Jackson plant. Bentham, Flora Australiensis, ii., 36, describes the ovary as sessile, but New South Wales specimens examined by us showed the ovary to be very slightly stipitate. The ovary in the Crow's Nest plant is shortly but more markedly stipitate, the stipes being very prominent in the fully developed pod.

Isotropis Wheeleri F. v. M. Thargomindah, Dr. W. MacGillivray, 3/9/23 (in flower). Recorded for Queensland by J. M. Black in " Flora of South Australia " p. 295, but no specific locality record given.

Swainsona parviflora Benth. Wide Bay, J. C. Bidwill ; Mt Perry, Burnett District, Jas. Keys ; Silverwood, Darling Downs, C. T. White.

Swainsona parviflora var **vesita** n. var. Folia ramulique pilis sericeis obsita.

Plants clothed in nearly all parts with a light coloured, rather silky pubescence.

Locality : Near Adavale, Western Queensland. Dr. W. MacGillivray, 28/8/1923.

Swainsona oligophylla F. v. M. ex Benth Fl. Austr. II. 219 (1864) ; S. concinna F. M. Bail. Q'land Agric. Journ. xxv. 286, pl. xxviii., Fig. ii. (1910). Georgina River, E. W. Bick ; near Nockatunga, Dr. W. MacGillivray ; Isisford, Western Queensland, —. Parkinson. A comparison of Bailey's *S. concinna* during an examination of Swainsona material in the Queensland Herbarium convinced us of its identity with Mueller's *S. oligophylla*. This species is also found in Central Australia and Western New South Wales.

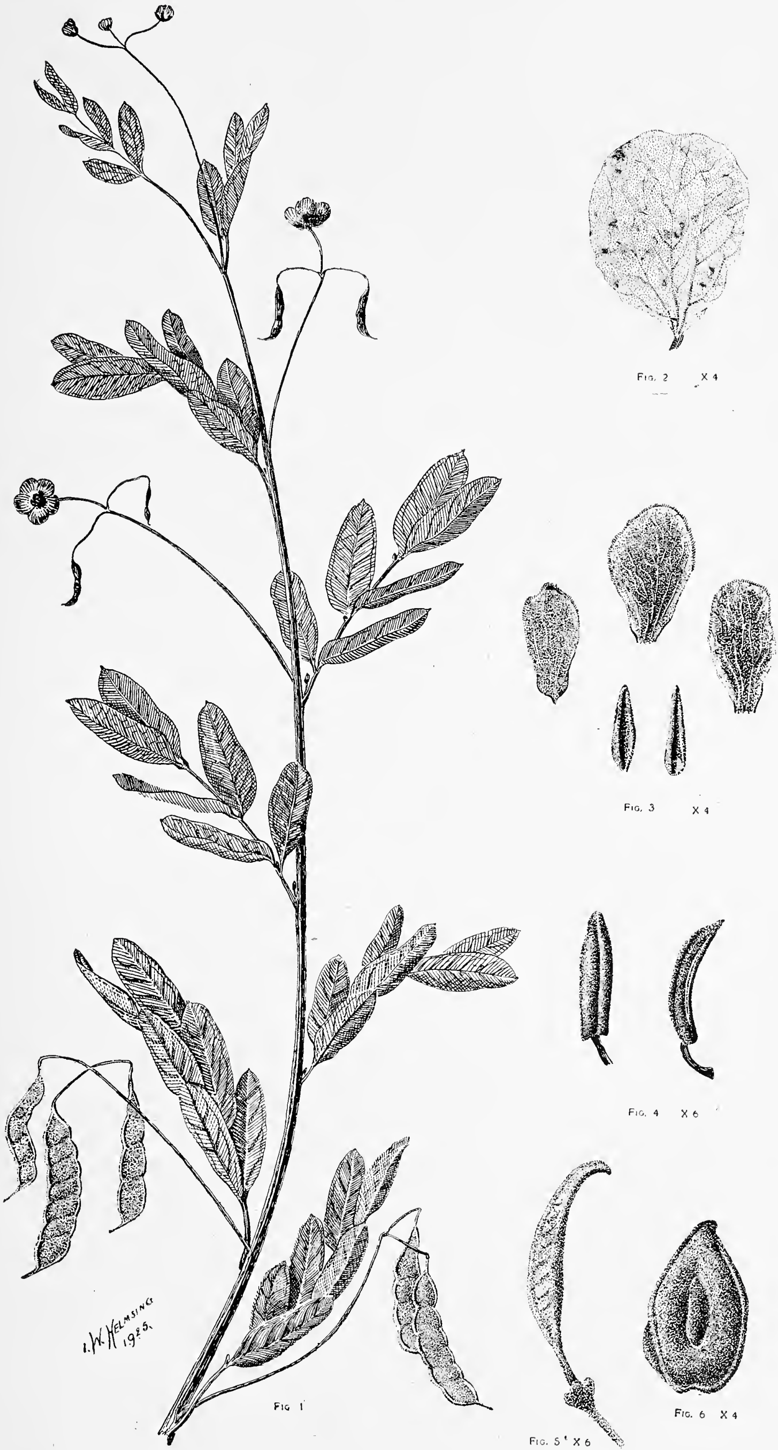
Desmodium scorpiurus (Sw.) Desv. Naturalised in the Mossman District, North Queensland ; supposed to have been introduced from Samoa (Howard Newport).

A native of Tropical Asia, naturalised in the Philippines and in Polynesia (E. D. Merrill, "Flora of Manila," p. 239).

Cassia neurophylla (new species). (Plate IV.)

Frutex parvus pubescens vel fere glaber ; ramulis 4-vel 5-angulatis ; stipulis setaceis ; foliis 2-3-jugis, foliolis obliquis ellipticis ad apicem mucronatis subtus pallidis vel subglaucescentibus nervis utrinque prominentibus glandulis linearibus inter omnia paria ; inflorescentiis axillaribus umbellatis 2-5 floribus, pedunculis tenuis, bracteis deciduis, linearibus ciliatis ; pedicellis tenuis ; sepalis exterioribus linearibus interioribus late obovatis ; petalis flavis obovatis ; staminibus 10 subæqualibus ; ovario glabro stipitato, legumine pubescente vel glabro stipitato (stipite 2-4 mm. longo) plano falcato utrinque reticulato ad apicem rostrato, seminibus ad 7 transversis atro-fuscis ovatis.

A small shrub, pubescent or nearly glabrous. Branchlets 4- or 5-angled. Leaves of 4-6 leaflets. Stipules setaceous, 2 mm. long. Petioles 4-6 mm. long. Petiolules ·5-1 mm. long. Leaflets obliquely elliptical, base oblique, apex mucronate, the midrib and 5-7 lateral veins prominent on both sides, underside paler or glaucescent, 1·3–3·2 cm. long, 2-3 times as long as broad. Glands on the rhachis between the leaflets of each pair linear, about 1 mm. long. Flowers in axillary umbels of 2-5 flowers. Peduncles slender, 2·5–6·4 cm. long. Bracts at the apex of the peduncles deciduous, linear, ciliate, 1–1·5 mm. long. Pedicels slender, 6-10 mm. long. Flowers



Cassia neurophylla (new species). 1, about natural size ; 2, petal × 4 ; 3, sepals × 4 ; 4, stamens × 4 ; 5, ovary × 6 ; 6, seed × 4.

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glabrous except margins of sepals. Sepals obtuse, margins ciliate, varying in same flower from lanceolate to broadly obovate and from 2-4 mm. in length. Petals yellow, obovate, 8 mm. long. Stamens 10, almost equal, anthers 3 mm. long, filaments 1–1·5 mm. long. Ovary glabrous, on a stipes nearly 2 mm. long. Pods pubescent or glabrous on a stipes of 2-4 mm., flat, falcate, margins nerve-like and sinuous, surfaces marked by regular transverse depressions and fine reticulate veins, apex rostrate; size 3·2–3·8 mm. long, 6-8 mm. broad. Pod containing up to 7 seeds. Seeds transverse, dark brown, ovate, flattened, with a prominent central linear depression on each side, 5 mm. long and 4 mm. broad.

Locality: Sandstone Ranges, Settlement Creek near the Queensland-Northern Territory border, L. Brass. Flowering and fruiting in February, 1923. This new species belongs to the section *Psilorhegma* and is allied to *C. australis* from which it differs in its fewer and broader leaflets, smaller flowers and narrower bracts.

Acacia patens F. v. M. Charleville, Western Queensland, Dr. W. MacGillivray, 26/8/23 (in flower). A new record for Queensland; previously known from North-Western Australia and the Northern Territory. Our specimen lacks pods but we have little doubt of the determination.

Acacia uncifera Benth. Torrens Creek, J. E. Young (Wilkins's Expedition): A new locality for a little-known plant. Mr. Young's specimens bore a few pods (not quite fully matured). Pods (unripe) covered with a short soft tomentum, 3·7–6·2 cm. long, 8 mm. broad; margins undulate, sometimes here and there constricted between the seeds.

Order ROSACEÆ.

Rubus alceæfolius Poir. A new record for Queensland. Very common about Babinda, North Queensland, scrambling over trees along roadsides and edges of "scrub" (rain forest), where it was collected by C. T. White. Previously known from Assam, Burma, Malay Peninsular, Sumatra, and Java, and may be naturalised in North Queensland. We are indebted for the determination to Mr. T. A. Sprague, Royal Botanic Gardens, Kew, who writes that Focke separates the common Australian Rubus previously placed under *R. moluccanus* as a distinct species and adopts F. Mueller's name of *R. Hillii*. Unfortunately we have not available a copy of Focke's monograph (Species Ruborum, Bibliotheca Botanica, Heft 72, 1910) for reference.

Order SAXIFRAGACEÆ.

Quintinia Quatrefragesii F. v. M.

Capsules (previously unknown) on pedicels of 4-8 mm., hemispherical, 2·6 mm. in breadth, minutely 5-costate, each costa ending at the rim in a minute, gland-like calyx-tube, valves 3-4, the erect styles about 1 mm. long; stigmas separating. Described from specimens collected on Bellenden Ker Range by C. T. White in January, 1923.

Polyosma rhytophloia (new species). (Plate V.)

Arbor parva ramulis juvenilibus pubescentibus ad nodos complanatis ; foliis oppositis petiolatis, laminis submembranaceis ellipticis ad apicem acute acuminatis marginibus serratis nervis subtus in sicco prominentibus ; spicis terminalibus ; floribus puberulis omnibus bractea ovata et bracteolis duabus parvis instructis ; calycibus ferrugineis, tubo campanulato ca. 2 mm. longo, limbo 4-lobato lobis deltoideis ; petalis 4 in paribus coherentibus oblongis obtusis ; staminibus filamentis puberulis, antheris glabris ; stylo tenuo puberulo, stigmate 2-lobato, lobis minutis globosis ; fructu (verisimiliter immaturo) globoso ca. 6 mm. diam.

A small tree attaining about 9 metres in height and a stem diam. of about 15 cm. Bark greenish grey with conspicuous lighter-coloured wrinkles, brown when cut. Young shoots and inflorescence pubescent. Young branchlets flattened at the nodes. Leaves opposite, elliptical, prominently and acutely acuminate at the apex, margins serrate, thin or submembranous in texture, midrib, lateral nerves and large reticulate veins visible on both surfaces but more conspicuous and raised on the underside, measurement of the leaf blade, 9-14 cm. long, 3-4 times as long as broad ; petioles 9-21 mm. long. Spikes terminal, 5-10 cm. long. Flowers puberulent, each one subtended by an ovate bract about 1·5 mm. long with 2 ovate bracteoles scarcely 1 mm. long, one on each side of the bract. Calyx ferruginous pubescent ; the tube campanulate, 2 mm. long ; lobes 4, deltoid, about 1 mm. long. Petals 4, coherent or adnate in pairs, oblong, obtuse, 8-10 mm. long. Stamens 6-8 mm. long ; filaments puberulent ; anthers glabrous. Style slender, puberulent, 6-8 mm. long divided at the apex into 2 minute, globose, stigmatic lobes. Fruit (probably immature) globose, about 6 mm. in diameter, containing a single seed.

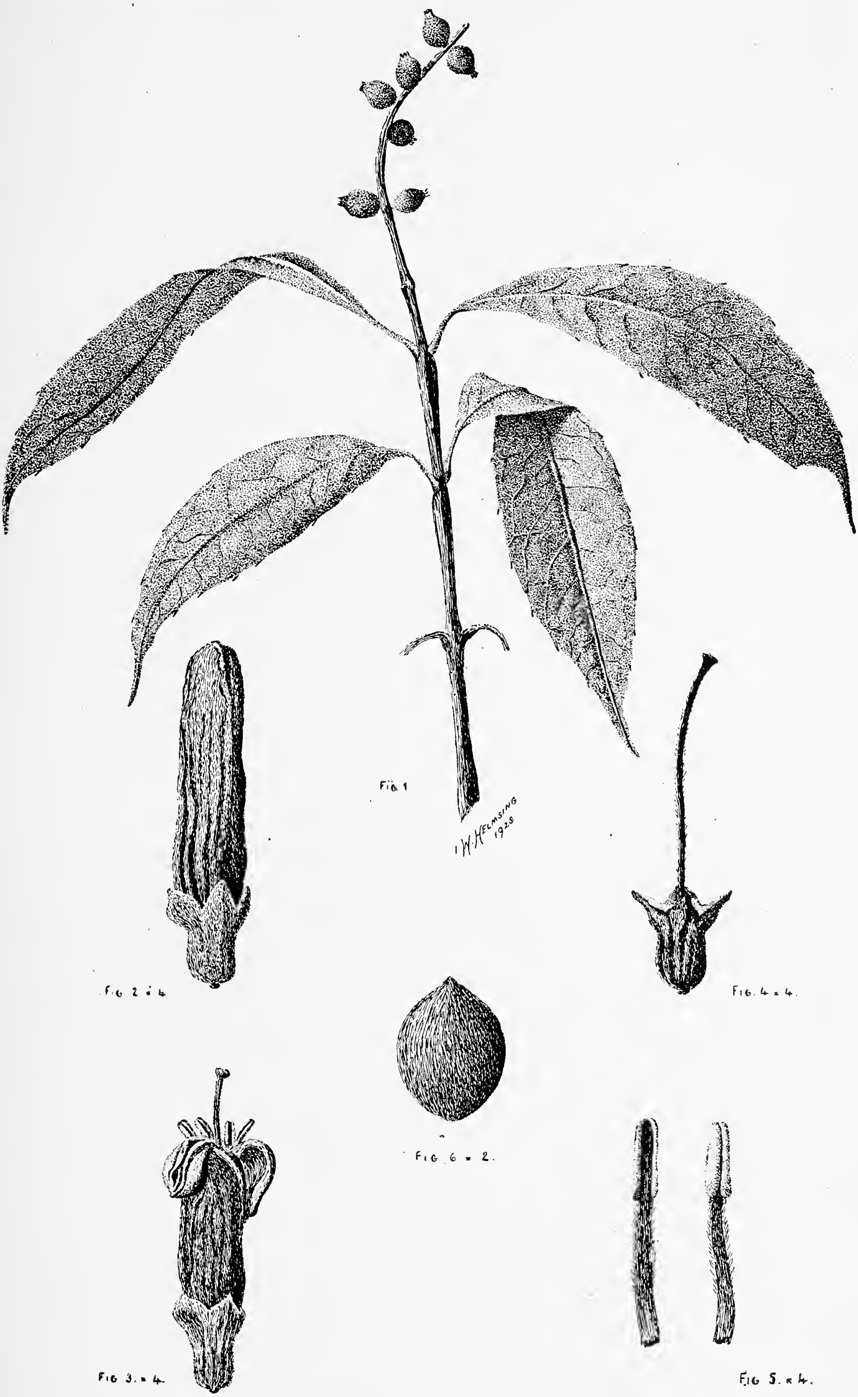
Locality : Eungella Range, about 40 miles westward of Mackay, W. D. Francis, October 3rd to 12th, 1922 (flowering specimens, type) ; A. H. Cole ; W. Macartney (specimen with fruit) ; Boonjie, C. T. White, January, 1923 (fruiting specimens).

This species is allied to *Polyosma hirsuta* C. T. W. from which it is distinguished by its sessile flowers and less dense indumentum.

Order MYRTACEÆ.

Agonis lysicephala F. v. M. and Bail.

Flowers (previously unknown) in terminal dense globose heads, 8 mm. in diam. Bracts subtending flowers, ovate or orbicular, concave, on a short claw, pubescent on the back, about 2 mm. long. Flowers sessile. Calyx tube hoary, broadly campanulate, angular by compression, about 2 mm. long. Calyx lobes 5, glabrous or margins slightly ciliate, broad and rounded, about 1 mm. long. Petals 5, glabrous, obovate or orbicular, 2·4 mm. long. Stamens exceeding 20, in a continuous series, the longer filaments about 1·4 mm. long. Summit of ovary hoary ; style glabrous,



Polyosma rhytophloia (new species). 1, fruit-bearing twig about one-half natural size; 2, flower bud × 4; 3, flower × 4; 4, flower with petals and stamens removed; 5, stamens × 4; 6, seed × 4.

about 2 mm. long; stigma entire, slightly capitate. Described from specimens collected in sandy country, Temple Bay, Cape York Peninsula, by Mr. J. E. Young, who describes the species as a small tree.

As the type specimens of *Agonis lysicephala* in the Queensland Herbarium are without leaves, there is a little doubt as to whether the specimens described above belong to *Agonis lysicephala.* If the specimens do belong to this species the assumption that it has only ten stamens is incorrect. This assumption has been used in compiling the keys to the genus appearing in the "Queensland Flora" ii., 586, and "Botany Bulletin" xxii., 22. The position of the species in the key in the above "Botany Bulletin" is nearest to that of *Agonis elliptica* W. &. F., from which species it is distinguished by its narrower leaves and hoary summit of the ovary.

Eucalyptus Caleyi Maiden. Stanthorpe District, Southern Queensland, W. R. Petrie. A new record for Queensland; previously only recorded for New South Wales.

Eucalyptus Morrisii R. T. Baker. Paroo-Bulloo Range, Western Queensland, Dr. W. MacGillivray, 29/8/1923. A new record for Queensland. Previously recorded from New South Wales. In Dr. MacGillivray's specimens the capsules were smaller and on larger pedicels than in typical *E. Morrisii*, approaching some forms of *Eucalyptus exserta.* Specimens were, therefore, referred to Mr. J. H. Maiden, the leading authority on the genus, and he coincided in the identification.

Xanthostemon Youngii (new species). (Plate VI.)

Arbor parva partibus junioribus pubescentibus vel canescentibus; foliis alternis sæpe confertis petiolatis, obovatis vel oblanceolatis utrinque reticulatis ad apicem obtusis marginibus subrecurvis; floribus (in sicco atrosanguineis) ad apices ramulorum confertis solitariis et pedunculatis vel in cymas breves dispositis, pedunculis et pedicellis pubescentibus, pedunculis unifloris ·8–1·2 cm. longis, bracteis et bracteolis linearibus vel spathulatis; calycibus discoideis extus pubescentibus 1·9 cm. diam. tubo cum quinque tuberculis hemisphæricis cum quinque lobis alternantibus, lobis late deltoideis parvis (3 mm. longis); petalis breviter unguiculatis, lamina orbiculari ciliata, ungue brevi et lato; staminibus numerosissimis (ca. 80) uniseriatis illis exceptis calycis lobis oppositis; antheris ovatis ad basem cordatis; ovario dense tomentoso globoso 4-loculari stylo glabro; capsula pubescenti vel tomentosa globosa vel ovoidea; seminibus 8-12 in omnibus loculis.

A tree attaining a height of 12 metres in the forest, but flowering as a shrub 2·4 metres high on wind-swept beach ridges (J. E. Young). Young buds, pedicels and calyces pubescent or hoary. Leaves alternate, often crowded. Petioles 6-12 mm. long. Leaf blade elliptical, obovate or oblanceolate, apex obtuse, margins slightly recurved, midrib, lateral nerves and reticulate veins prominent on both sides, 5-12 cm. long, 2-3 times as long as broad. Flowers crowded on the ends of the branchlets, singly pedunculate or occasionally in very short cymes. Bracts and bracteoles at base of peduncles linear or spathulate, pubescent, 4-5 mm.

long. Single flowered peduncles 8-12 mm. long, pubescent. Calyx disc-shaped, pubescent on the underside, 1·9 cm. in diameter, the tube with 5 saccate or hemispherical protuberances alternating with 5 broad, deltoid lobes about 3 mm. long. Petals orbicular, ciliate, red, 6-8 mm. in diameter, inserted on the margin of the calyx between the lobes by a short broad claw about 2 mm. long and 2 mm. broad. Stamens red, about 80, in a single series except at each point opposite the calyx lobes where there are 4-6 stamens inserted on the raised area between the adjacent protuberances of the calyx tube. Filaments red, about 2·5 cm. long. Anthers ovate, abruptly acuminate, cordate at base, 2 mm. long. Ovary densely tomentose, globose, attached to calyx tube by its broad base, 4-celled. Style red, glabrous, slender about 2·5 cm. long. Capsule pubescent or tomentose, seated on the reflexed calyx which retains its saccate protuberances, globose or ovoid, obscurely 4-lobed, 1·2–1·4 cm. in diameter. Seeds 8-20 in each cell, flattened, subtriangular, 3-4 mm. broad.

Locality: Temple Bay, Cape York Peninsula, J. E. Young, Wilkins's Expedition, July, 1923.

This new species is distinguished from the previously described Australian ones by its brilliant red filaments and large disc-shaped calyx-tube with its 5 downwardly directed hemispherical protuberances. The specific name is dedicated to the collector.

Eugenia Banksii Britten & S. Moore. Fruit previously unknown.

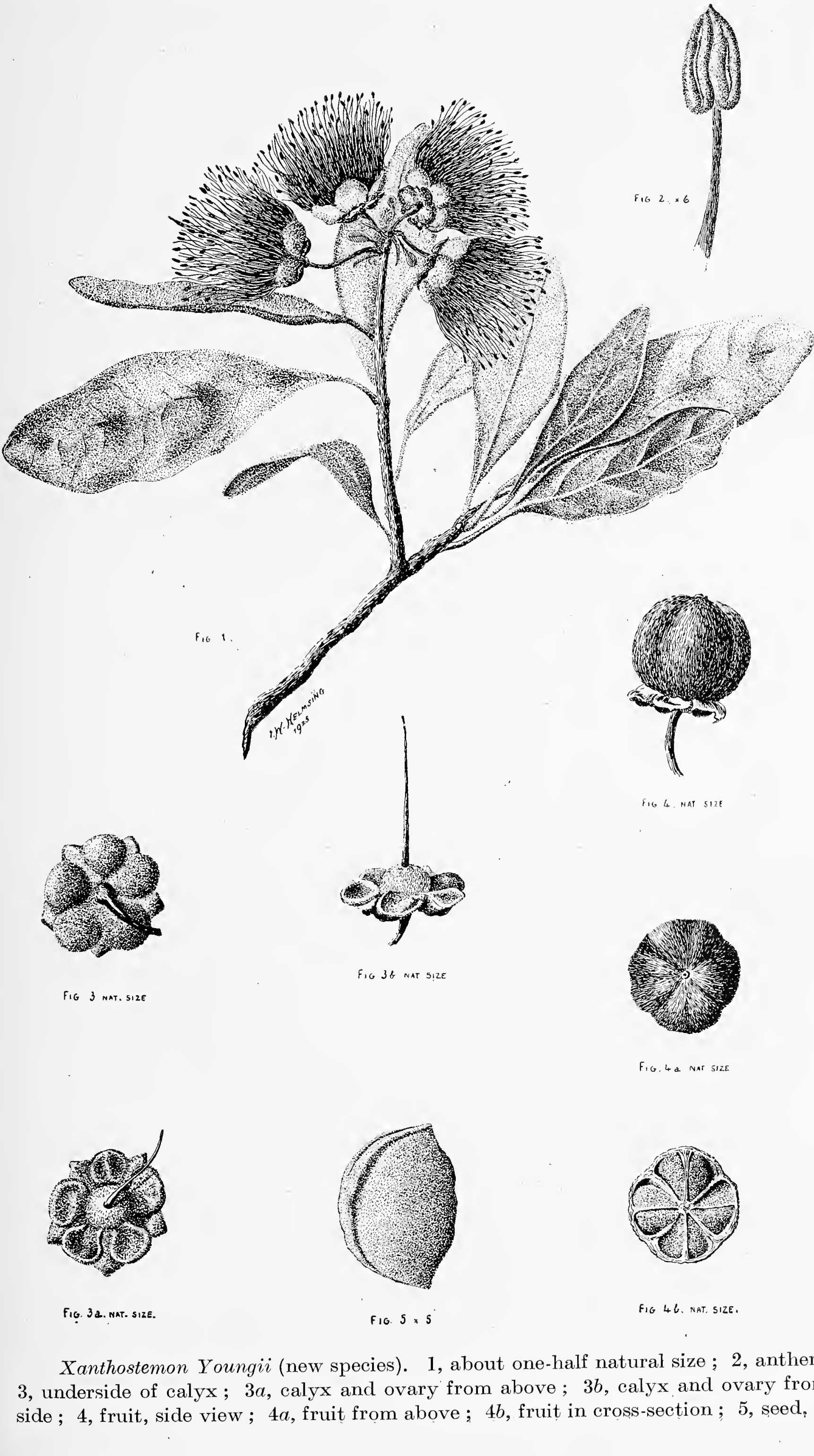
Dry fruits sessile or on pedicels of 1 mm., black or dark purple, ovoid, 8-12 mm. long, 5-8 mm. broad, crowned by the circular rim of the calyx tube which bears 5 or sometimes 4 obscure lobes; seeds 2, superposed, globose, about 4 mm. in diameter. Described from specimens collected at Cape Bedford, near Cooktown, by N. A. R. Pollock, who describes the species as a tree producing edible and palatable fruit.

Myrtus metrosideros Bail.

Fruit (previously unknown) single in the axils on recurved pubescent peduncles 3-5 lines (6-10 mm.) long, globose, hoary pubescent, 4-6 mm. diam., crowned by 5 pubescent, orbicular calyx lobes about 2 mm. long. As no mature seeds or dissepiments were found in the interior possibly they have been destroyed by decomposition. Described from specimens collected on the central peak of Bellenden Ker Range, by C. T. White. The species was originally described from leaves only.

Order MELASTOMACEÆ.

Tristemma virusanum Comm. A new record for Queensland. Naturalised and very common about Babinda, North Queensland; J. F. Illingworth, C. T. White. A native of Madagascar, Mauritius, and Bourbon. Rather fragmentary specimens of this plant were sent in April 1921 by Mr. J. F. Illingworth and lately one of us (C. T. White) when in North Queensland, gathered good material and noticed that the plant was very common along the roadsides in the low-lying country between Gordonvale and Babinda, North Queensland. The determination has been verified by the Director, Royal Botanic Gardens, Kew.



Xanthostemon Youngii (new species). 1, about one-half natural size ; 2, anther ; 3, underside of calyx ; 3*a*, calyx and ovary from above ; 3*b*, calyx and ovary from side ; 4, fruit, side view ; 4*a*, fruit from above ; 4*b*, fruit in cross-section ; 5, seed.

ORDER CUCURBITACEÆ.

Citrullus colocynthis Schrader. Naturalised about Townsville; C. T. White. An Asiatic and African plant which is a new record for the State.

ORDER LYTHRACEÆ.

Ammannia crinipes F. v. M. Settlement Creek, N.W. Queensland; L. Brass.

A new record for Queensland; previously only known from the Northern Territory.

ORDER RUBIACEÆ.

Randia disperma Moore.

Fruits (previously unknown) purple, ovoid or globose 12 mm. long, crowned by the persistent calyx tube which measures about 4 mm. long and 4 mm. in diameter. Seeds 2 in each cell, flattened on two sides and curved on the back, 8 mm. long, 4-5 mm. broad.

Fruits described from specimens collected at an altitude of about 2,000 feet on the Bellenden Ker Range, by C. T. White.

ORDER COMPOSITÆ.

Eupatorium rivularum Regel. This South American plant has run out in one or two places near Brisbane.

Elephantopus spicatus Aubl. Palm Island, N. Queensland, J. H. Simmonds, junr. This tropical American plant, naturalised as a weed in parts of eastern Asia, has not previously been collected in Queensland.

ORDER SAPOTACEÆ.

Sideroxylon singuliflorum (new species). (Plate VII.)

Arbor parva; ramulis junioribus pubescentibus pilis ferrugineis; foliis glabris, petiolatis, glabris oblanceolatis utrinque nervis primariis prominulis præcipue subtus; floribus axillaribus solitariis vel raro duobus in axilla; pedicellis ad apicem sensim incrassatis; calycis lobis 5 imbricatis ovatis vel orbicularibus obtusis exterioribus majoribus intus pubescentibus pilis longis ferrugineis interioribus minoribus utrinque pubescentibus; corolla (in gemma modo visa) glabra; staminibus ad tubi basem insertis; antheris ovatis, ovario ad basem ipsam pilis longissimis obsito, stylo glabro.

A small tree. Young shoots and young branchlets ferruginous pubescent. Petioles 2-5 lines (4-10 mm.) long. Leaf blades oblanceolate or narrowly elliptical, apex obtuse, base cuneate, midrib and lateral nerves visible on both sides but more prominent on the underside, primary nerves 5-8 on each side of midrib, 5–7·5 cm. long, 2·5–3 times as long as broad. Flowers immature, axillary, 1 or rarely 2 in each axil. Pedicels 1·7–3 cm.

long, gradually thickened towards apex. Calyx lobes 5, imbricate, ovate to orbicular, obtuse, ferruginous pubescent inside, the inner ones pubescent on the outside, 5 mm. long. Corolla glabrous, 6·6 mm. long, lobes apparently about 2 mm. long. Stamens inserted towards base of corolla tube ; anthers ovate, nearly 2 mm. long ; filaments about 1·2 mm. long. Ovary densely hirsute on margin at base, tapering into a glabrous style, the ovary and style together measuring 6 mm. long.

Locality : Bellenden Ker, near the summit, C. T. White, January, 1923.

Unfortunately the buds are too immature to allow a complete description of the flowers to be made. There appear to be scales in the throat of the corolla but their number and form could not be determined. Under the circumstances the assignment of the specimens to *Sideroxylon* is somewhat doubtful, although their appearance resembles that of the Australian species of *Sideroxylon*. The species is somewhat remarkable among the Queensland species on account of its long pedicels, mostly solitary in the axils.

ORDER MYOPORINEÆ.

Pholidia Dalyana F. v. M. Near Wilson River, South-Western Queensland, Dr. W. MacGillivray, in full flower 4/9/1923 ; a specific locality for a plant rare in Queensland.

Eremophila oppositifolia R. Br. Warrego Range, South-Western Queensland, Dr. W. MacGillivray, 24/8/23. A new record for Queensland. The specimens have rather broader leaves than usual (averaging about 4 mm. broad) ; the corolla is pubescent, not glabrous, inside as described in the " Flora Australiensis," but specimens in the Queensland Herbarium from New South Wales and South Australian localities also possess this character. Dr. MacGillivray's specimens agree almost exactly with some New South Wales material from the National Herbarium, Sydney. In answer to enquiries Mr. A. Morris of Broken Hill, New South Wales, also informs us that the typical flower is " creamy white with a purple blush on the upper surface of the corolla ; but some specimens have no purple spot." Dr. W. MacGillivray also says that he has collected a form with purple flowers and calyx.

Eremophila oppositifolia R. Br. var. **rubra** (new variety).

Flores quam in typo minores, calycis segmentis 9 mm. longis ca. 2 mm. latis, corolla rubra fere 2·5 cm. longa 1·3 cm. lata.

Flowers smaller than in the type, calyx segments 9 mm. long and about 2 mm. broad at the broadest part ; corolla red, nearly 2·5 cm. long and 1·3 cm. broad.

Near Wilson River, South-Western Queensland, Dr. W. MacGillivray, 4/9/1923. The following key shows the chief differences between the type and variety.

Calyx segments 1·3–1·7 cm. long, 5 mm. broad; corolla white to purplish Type
Calyx segments ·8 cm. long, 2 mm. broad, corolla red .. .. .. Var. *rubra*

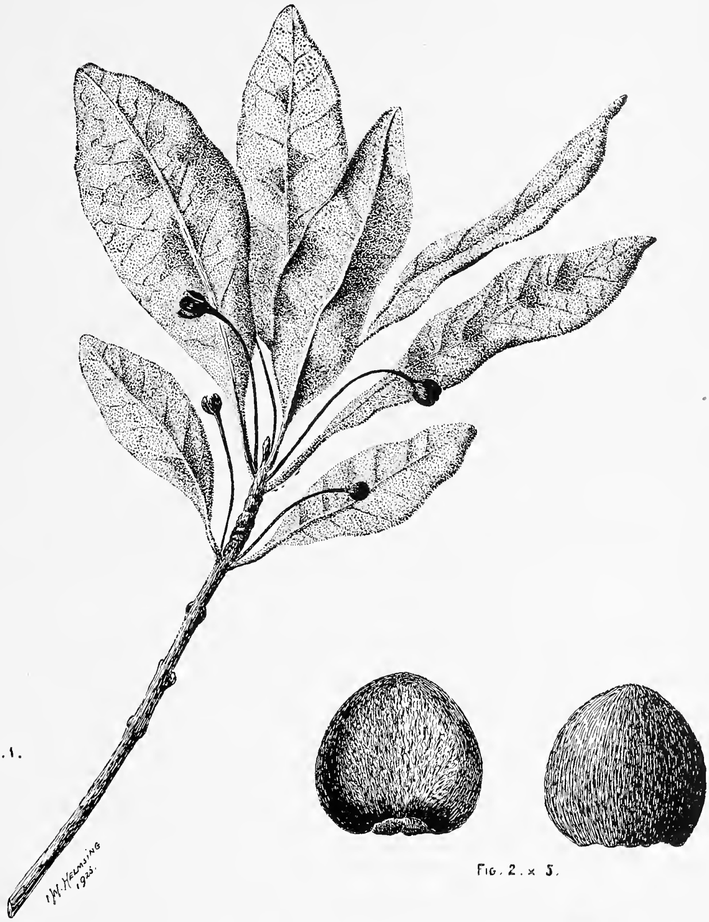


FIG. 1.

FIG. 2. × 5.

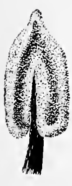


FIG. 3. × 10.

FIG. 4. × 2.

FIG. 5 × 4.

Sideroxylon singuliflorum (new species). 1, about one-half natural size ; 2, calyx lobes ; 3, anther ; 4, bud ; 5, flower, with calyx and corolla removed.

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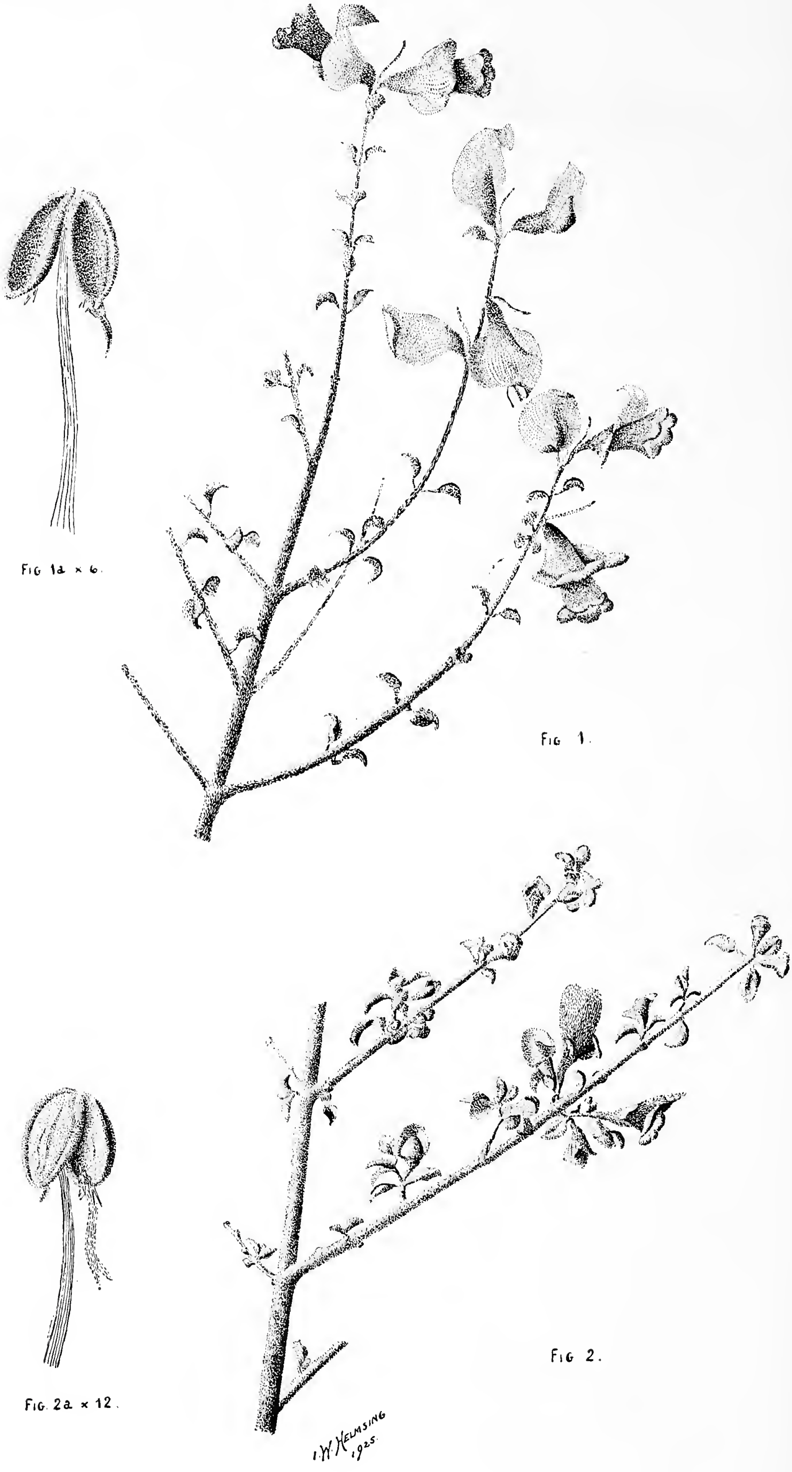

Fig. 1, *Prostanthera megacalyx* (new species), about natural size. Fig 1*a*, anther × 6.
Fig. 2, *Prostanthera suborbicularis* (new species), about natural size. Fig. 2*a*, anther × 12.

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Family LABIATÆ.

Prostanthera megacalyx (new species). (Plate VIII., fig. 1.)

Frutex vel suffrutex, ramulis juvenilibus pilis brevibus albis glandulosis obsitis ; foliis suborbicularibus in sicco sæpe incurvatis vel conduplicativis breviter petiolatis ; floribus axillaribus solitariis breviter pedicellatis, bracteolis anguste linearibus ; calycibus glanduloso-punctatis, tubo striato, limbo manifeste bilabiato ; labio superiore majore (1·5 cm. longo 1 cm. lato), inferiore dimidio breviore ; corollis purpureis vel violaceis extus pubescentibus, tubo intus lineis atro-purpureis striato ca. 1 cm. longo, limbo bilabiato, labio superiore breviter 2-dentato, labio inferiore 3-lobato, lobo intermedio longiore retuso (5 mm. longo 3 mm. lato) ; antheris pupureis, connectivi calcare altero brevi altero elongato ; pistillo glabro.

Shrub or undershrub branchlets and young growth clothed with short, white, crisped, glandular hairs. Leaves very prominently and thickly glandular-dotted, thickly coriaceous, irregularly suborbicular, mostly much incurved and somewhat conduplicate in the dried state ; petiolate, blade 3-6 mm. long, 2-4 mm. broad, tapering into a petiole of 1-2 mm., the floral ones not obviously smaller. Flowers solitary in the upper axils on pedicels of about 1 mm. Bracteoles at base of calyx tube narrow linear, 5 mm. long. Calyx glandular-dotted with small rather scattered glands ; tube striate, 4 mm. long ; upper lip broadly ovate, 1·5 cm. long, 1 cm. broad, lower lip ½ or somewhat less the size of the upper, both enlarging considerably in fruit and becoming pale-coloured and hyaline. Corolla purple or violet, pubescent with short rather scattered hairs ; tube about 1 cm. long, streaked with short, dark purple lines inside ; upper lip shortly 2-lobed, lower lip deeply 3-lobed, middle lobe blunt, 5 mm. long, 3 mm. broad. Anthers purplish, 2 mm. long, the longer appendage hyaline and produced for about 1 mm. below the anther. Ovary glabrous ; style 1·2 cm. long.

Locality : Quilpie, Western Queensland, Mrs. A. E. Deane.

Mrs. Deane writes " This shrub grows on the side of a very rocky ridge and has been flowering since August when I first noticed it. So far I have only seen it in one locality."

Prostanthera suborbicularis (new species). (Plate VIII., fig. 2.)

Frutex vel suffrutex dense tomentosus ; foliis parvis petiolatis coriaceis suborbicularibus planis vel in sicco conduplicativis ; floribus solitariis axillaribus breviter pedicellatis, bracteolis anguste linearibus vel fere setaceis ; calycibus tomentosis, tubo substriato, limbo bilabiato, labiis subæqualibus orbicularibus ; corollis extus pilosis intus glabris vel glabrescentibus, limbo bilabiato, labio superiore 2-lobato lobis obtusis, labio inferiore 3-lobato lobo medio emarginato ; antheris ca. 1 mm. longis, connectivi calcare altero brevi altero elongato ; ovario ad apicem pilis albo-hyalinis tenuiter obsitis, stylo glabro.

A shrub or undershrub, finely and densely tomentose. Branchlets terete. Petioles 2 mm. or less in length. Leaves sometimes crowded on short lateral branchlets, petiolate, petioles about 2 mm. long, blade coriaceous, orbicular or broadly elliptical, flat or conduplicate, ·7–1 cm. long, nerveless or the midrib and one or two nerves on each side slightly evident. Flowers solitary in the axils. Pedicels 2 mm. or less in length. Bracteoles at base of calyx tube, linear or almost setaceous, 2 mm. or less in length. Calyx tube campanulate, striate, nearly 4 mm. long; calyx lobes orbicular, the lower one 3 mm. in diameter, the upper one 4 mm. in diameter. Corolla pubescent on the outside, glabrous or nearly so inside, 1·3–1·5 cm. long; the tube nearly 8 mm. long; limb 2-lipped; the upper lip 2-lobed, lobes obtuse; lower lip 3-lobed, the middle lobe emarginate. Filaments 5 mm. long. Anthers about 1 mm. long, the two appendages of the connective furnished with a few hyaline setæ, the longer one produced beyond the base of the anther cell to a length of 1 mm. Ovary clothed with hyaline hairs around the base of the style. Style glabrous, curved at the apex, 6-8 mm. long.

Locality: Adavale, Western Queensland, Dr. W. MacGillivray, 29/8/1923.

The two new species described here both belong to Bentham's series Subconcavæ and differ from the described species in their small orbicular leaves. They might conveniently be placed at the end of the section along with *P. eurybioides* as under.

Leaves suborbicular, ovate, or oblong.

Plants nearly glabrous.

Bracts short and obtuse, calyx lobes nearly equal .. *P. eurybioides.*

Bracts narrow-linear, calyx lobes very unequal .. *P. megacalyx.*

Plants densely tomentose .. .. *P. suborbicularis.*

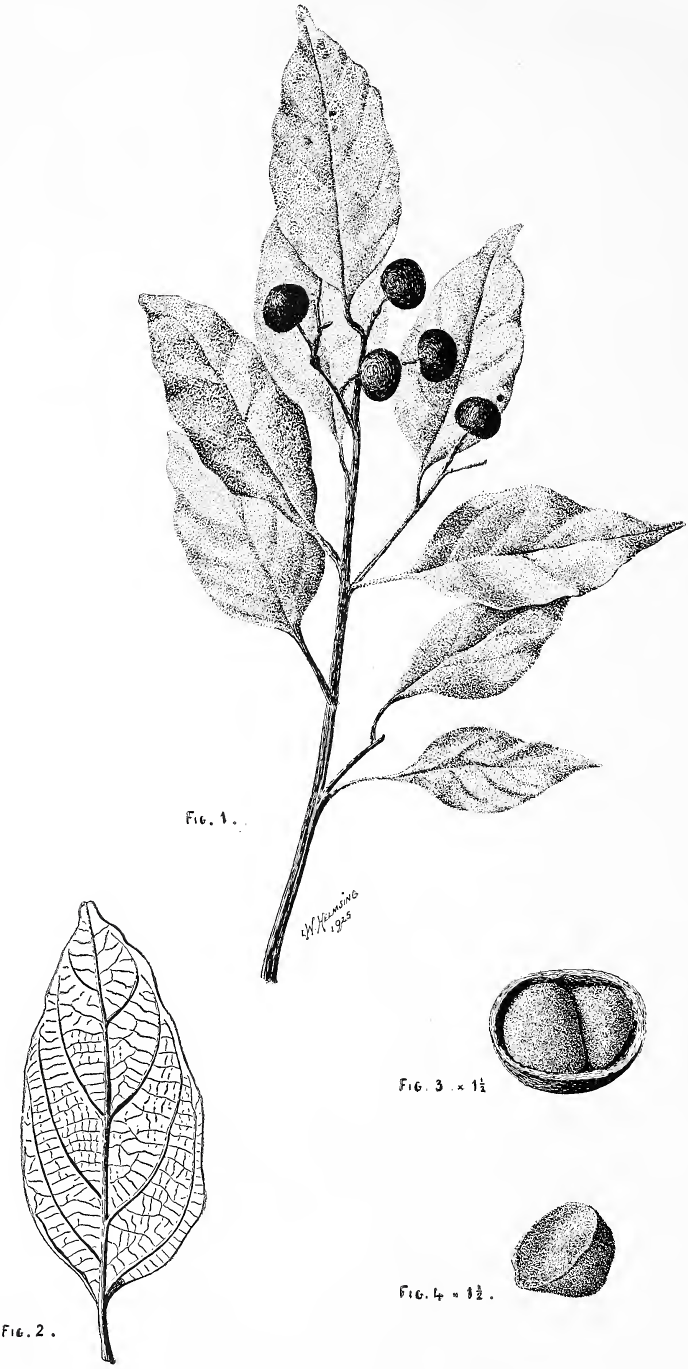
Order AMARANTACEÆ.

Gomphrena conica Spreng. Wednesday Island, Torres Strait, W. A. Haswell. A definite locality for this plant, which is apparently rare in Queensland.

Gomphrena leontopodioides Domin. Beitr. Fl.u. Pflazengeog. Austr. 1 Teil. 3 Abteil. Lief 1, p. 642,—Bibliotheca Botanica Heft 89. Darr River, Central West Queensland, R. A. Ranking; Bulloo River, South of Adavale, Western Queensland, Dr. W. MacGillivray. Three localities for a recently described species.

Order CHENOPODIACEÆ.

Atriplex velutinella F. v. M. Thargomindah, Western Queensland, Dr. W. MacGillivray. A new record for Queensland; previously recorded from New South Wales and South Australia.



Cryptocarya corrugata (new species). 1, about one-half natural size ; 2, underside of leaf, natural size ; 3, transverse section of fruit ; 4, a cotyledon.

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Order LAURACEÆ.

Cryptocarya corrugata (new species). (Plate IX.)

Arbor ad 30 m. alta, trunco 2/3 m. diam.; cortice fulvo; alburno in longitudinem corrugato; partibus junioribus ferrugineo pubescentibus; foliis petiolatis, ovatis acuminatis supra glabris subtus plus vel minus glaucis in sicco prominente nervosis glabris nervis majoribus exceptis; inflorescentiis paniculatis terminalibus vel axillaribus, paniculis plerumque quam foliis brevioribus; floribus nobis ignotis; fructibus nigris subglobosis compressis latioribus quam longis (ca. 1·3 cm. latis).

A tree attaining a height of 30 metres and a stem diam. of 60 cm. Stem not prominently buttressed. Bark brown, sometimes slightly corrugated or longitudinally wrinkled, when cut reddish brown, measuring 1·2 cm. thick on a tree with a stem diam. of 45 cm. Surface of sapwood strongly wrinkled or corrugated longitudinally (somewhat resembling the surface of a washing board). The corrugations or wrinkles in some cases of large trees are 9 mm. deep. Young shoots, branchlets and rhachis of inflorescence densely but shortly ferruginous pubescent. Branchlets angular or slightly sulcate towards the growing point. Leaves petiolate, glabrous except the main nerves on the underside which are often puberulous, generally more or less glaucous on the underside, ovate acuminate, venation obscure on the upper surface except for the immersed midrib and primary veins, midrib, primary veins and transverse veinlets conspicuous and raised on the underside; lamina 5–7·5 cm. long, about twice as long as broad; petiole 6-12 mm. long. No flowers available. Fruit black, not very succulent, arranged in terminal or axillary panicles generally shorter than the leaves, compressed, subglobose, broader than long, about 1·3 cm. broad.

Locality: Eungella Range, about 40 miles west of Mackay, October 1922, W. D. Francis (fruiting specimens, type), A. H. Cole (leaf specimens); Bellenden Ker, near summit of Central Peak, C. T. White (leaf specimens).

This species resembles *C. glaucescens* R. Br. in its compressed fruit, but is distinguished from *C. glaucescens* by its shorter leaves with fewer and more strongly raised primary veins on the underside.

Order PROTEACEÆ.

Grevillea sessilis (new species). (Plate X.)

Frutex erectus ca. 3 m. altus dense sericeo-tomentosus pilis sæpe fuscis; foliis 10-18 cm. longis petiolatis (petiolis 1·5–4·5 cm. longis, laminis 8·5–13·5 cm. longis) alte pinnatisectis, segmentis 9-13 lanceolatis vel lineari-lanceolatis acutis ad apicem mucronatis supra in sicco nervo medio prominenti et nervis secundariis numerosis obliquis prominulis; inflorescentiis terminalibus spicatis; spicis densifloris non secundis; floribus sessilibus solitariis vel geminatis; perianthii segmentis extus tomentosis intus glabris sub limbo revolutis; antheris ovatis; glandula hypogyna semiannulari margine sinuato; ovario sessili obliquo dense villoso; stylo glabro tenui folliculis ovoideis dense villosis.

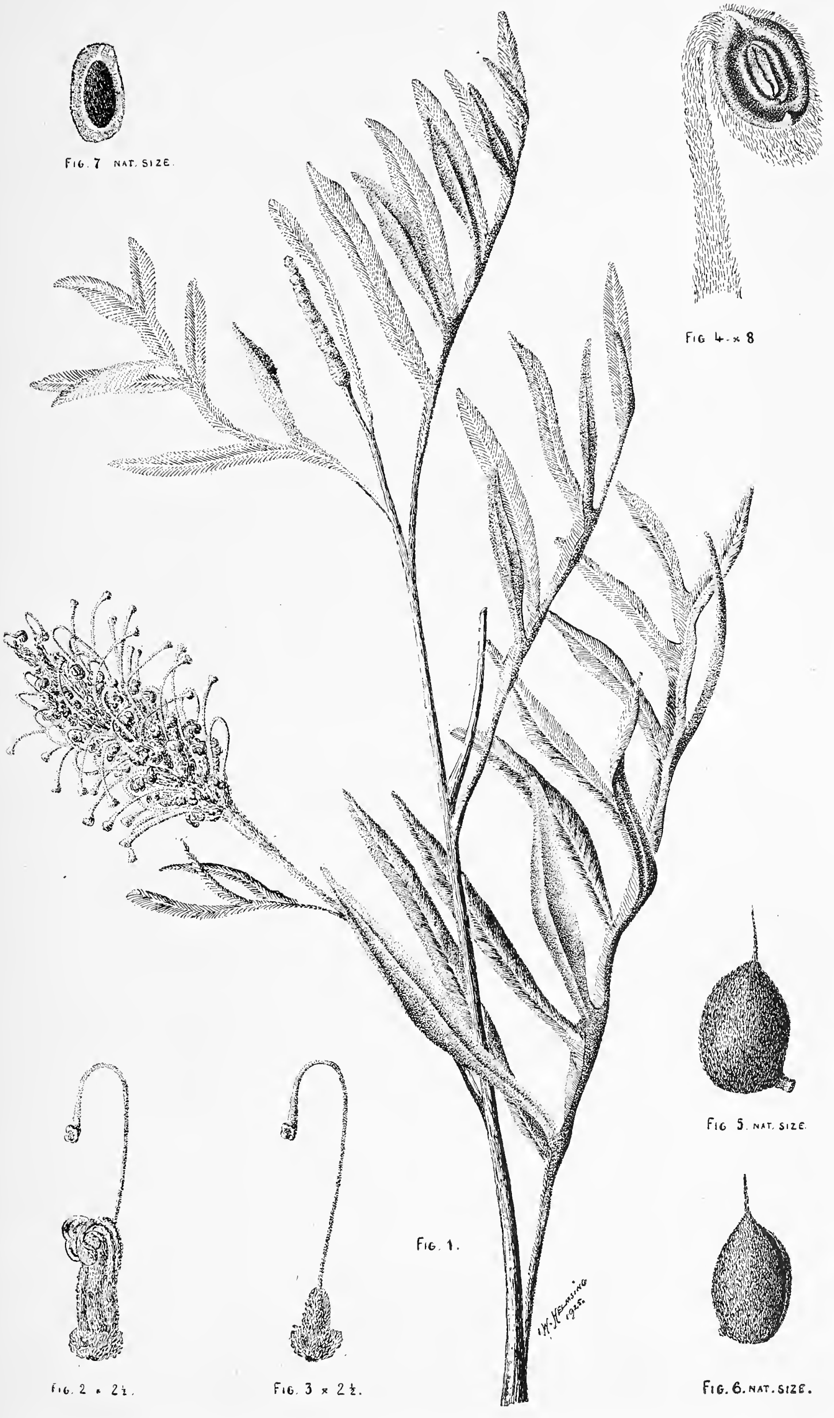
An upright shrub of about 3 metres in height. Young shoots, branchlets, underside of leaves and inflorescence tomentose and ferruginous in parts, the hairs appressed and silky on the branchlets and underside of leaves. Leaves deeply pinnatisect, divided almost to the rhachis, leaf segments 9-13, lanceolate or linear-lanceolate, acute and mucronate, midrib and numerous oblique primary nerves prominent on upper surface, the primary nerves obscured by the silky indumentum on the lower surface, leaf segments 2·5–7·6 cm. long, 6-10 mm. wide, petiole 2·5–4·3 cm. long, winged in the upper part, wing of rhachis attaining 4 mm. on each side. Inflorescence terminal, spicate, the spikes about 6·5 cm. long, the rhachis densely tomentose. Flowers sessile, singly disposed or approximated in pairs all round the rhachis. Perianth segments tomentose outside, glabrous within, revolute under the limb, 8-10 mm. long, scarcely 1 mm. broad, limb globose, about 2 mm. in diameter. Anthers ovate, ·7 mm. long. Gland semiannular, glabrous, its margin sinuate. Ovary sessile, oblique, densely villous; style glabrous, slender, 2 cm. long; stigmatic disc almost lateral, oval, 1 mm. long. Fruit sessile, the lower ones in the spike reflexed, oblique, ovoid, densely villous, 1·5–1·7 cm. long, 1 cm. broad, the slender persistent style over 2·5 cm. long, seeds 2 in each follicle, flattened, oblong oval, with winged margins, 12 mm. long, 7 mm. broad.

Locality: Torrens Creek, J. E. Young (flowering specimens, type); Mitchell's Pinch, between Mantuan Downs and Springsure, F. M. Bailey (fruiting specimens).

This new species belongs to the Series Hebegyneæ and is allied to *G. chrysodendron* R. Br. and *G. Banksii* R. Br., but differs from both of these species in its sessile flowers. From *G. chrysodendron* it is further distinguished by the shorter and broader segments of the leaves and non-secund inflorescence. From *G. Banksii* it is further distinguished by its smaller flowers. In the "Flora Australiensis" v., 434, and in the "Queensland Flora" iv., 1336, the flowers of *G. Banksii* are described as secund. In all the specimens examined by us the flowers are evenly distributed round the rhachis and are not secund. This non-secund character of the inflorescence of *G. Banksii* is also shown in Hooker's figure in the "Botanical Magazine," t. 5870, which represents a typical specimen of the species.

Order BIGNONIACEÆ.

Tecoma Oxleyi A. Cunn. Paroo-Bulloo Watershead, near Adavale, Western Queensland, Dr. W. MacGillivray. 29/8/1923. A new record for Queensland.



Grevillea sessilis (new species). 1, about one-half natural size; 2, flower × $2\frac{1}{2}$; 3, flower with perianth removed × $2\frac{1}{2}$; 4, anther inserted on perianth lobe; 5 and 6, fruit; 7, seed.

[*Face page* 166.]

In the "Flora Australiensis" Bentham reduced *T. Oxleyi* A. Cunn. to a synonym of the widely spread and very variable *T. australis* R. Br. In the "Trans. Roy. Soc. Sth. Austr." vol. xxxix., p. 836, J. M. Black, in a report on a collection of plants from the north-western regions of South Australia made by Captain S. A. White, separated *T. Oxleyi* from *T. australis*. In this he is followed by J. H. Maiden in his "Census of New South Wales Plants." *T. Oxleyi* differs from *T. australis* in being an inhabitant of arid, interior localities, in its very narrow leaflets and in its large flowers. We have not previously received specimens from any Queensland locality.

ORDER NAIADEÆ.

Triglochin calcitrapa Hook. Eaglehawk Swamp, Western Queensland, Dr. W. MacGillivray. A specific locality for a plant apparently rare in Queensland. In the "Queensland Flora" this plant is recorded for Queensland without specific locality as a variety of *T. centrocarpa* Hook. According to Fr. Buchenaum in his monograph of the genus (Engler's Pfalnzenreich) *T. centrocarpa* is a rare species confined to Western Australia.

ORDER FILICES.

Tænitis blechnoides Sw. Creek banks, near ranges, 15 miles west of Temple Bay, Cape York Peninsula, North Queensland, J. E. Young. A new record for Queensland; previously known from Tropical Asia, New Guinea, and Fiji.

Notes on Australian Flies of the Genus *Calliphora.*

By G. H. Hardy,

Walter and Eliza Hall Fellow in Economic Biology, Queensland University, Brisbane.

(*Read before the Royal Society of Queensland, 30th November,* 1925.)

Early in 1922, when first I paid attention to the taxonomy of the Australian Calliphorines, the absolute necessity to determine which of the many names should be applied to the common Australian species was so apparent that, in collaboration with Dr. T. Harvey Johnston, a preliminary synonymic list of names was compiled (these Proceedings, 1922). It was intended that this should be a forerunner to a revision of the genus *Calliphora,* treated much in the same way as that accomplished with the genus *Sarcophaga.* There was no time to complete the scheme before Professor Johnston left to take up his duties at the Adelaide University, and thereafter the matter was deferred.

With regard to status, there was nothing to indicate which of the numerous proposed genera would have to be amalgamated, and so the conservative policy was indulged in and certain species that had been long considered typical of the undefined genera were retained as such. Neither Dr. Johnston nor I had much faith in the values of the only characters we could find that would hold sufficiently well for the determination of these Australian groups, and such was indicated in the paragraph above the key that was then given. The main purpose of the paper was to definitely place as synonyms certain names that no amount of what is generally termed " splitting " could render acceptable under any other status.

The publication of this original synonymic list has had a very salutary effect. On account of it several letters have reached us pointing out weaknesses contained therein, chiefly to the effect that the characters given in the key for those genera adopted were found to grade with allied species found in other parts of the world. In these letters opinions expressed were unanimous upon the point that all species listed should have been included under one genus *Calliphora.*

The most important information came through Professor Johnston from Dr. J. M. Aldrich, who informed us that *Anastellorhina bicolor* was not a Calliphorine, and he sent characters taken from the type in support of this. Dr. Aldrich intends to publish upon this matter, and I have sent him the information that led us to include the name in the paper on the synonymy referred to.

It becomes apparent that *Neopollenia* must be substituted for *Anastellorhina*, and that *A. bicolor* Bigot must be deleted from that list. Also *Ochromyia* (*Proekon*) *lateralis*, to be found in the last and the first lines of pages 192 and 193 respectively, should be cancelled; the lines were accidentally inserted in these positions and overlooked in the proof.

W. S. Patton* has recently published the results of his studies of the types of these *Calliphora* which are situated in Europe, a class of paper that is always welcomed by Australian entomologists, who have only the descriptions—usually too inadequate—to guide them in the determination of Australian species. It is gratifying to note that, of the various synonyms suggested by Professor Johnston and myself, all generic and two specific names are maintained by Dr. Patton, but like others he has considered it expedient to place all the species under the one generic name. The type of one species was not found by him and a second is not mentioned, whilst *A. bicolor* is retained as a synonym but attached to an allied species to which the description does not conform.

There are, however, several matters in Patton's paper that do not conform to the knowledge of the blowflies that has been acquired in Australia. *Calliphora quadrimaculata* Swederus, to which *C. dasyophthalma* and *C. testaceifacies* Macquart are placed as synonyms, is stated to be "a common Tasmanian blowfly." Surely this should have been New Zealand, where the species abounds, and although *C. testaceifacies* is recorded from Tasmania (I cannot make the description agree) I have not seen the New Zealand form from there. I lived for five years in the island without meeting it, and during a recent visit collecting blowflies I again did not find it.

I believe the list of Australian species of *Calliphora* given below will be acceptable tentatively to most Australian workers on blowflies. The synonymy is amended from Patton's paper and such other sources of information as I have to hand.

Key to the Species of Australian Calliphora.

1. Eyes hairy; reddish or yellowish brown species 2
   Eyes bare; colour variable 3
2. Dorsum of thorax black with slight silvery tomentum that extends on to the head .. .. *hyalipennis* Macq.
   Dorsum of thorax completely covered with yellowish tomentum that is traceable on the head .. .. *ochracea* Schiner.
3. Abdomen yellow with blue stripe; thorax black.. .. .. *augur* Fabr.
   Abdomen never with yellow (except hairs), usually blue, green, or bronze .. 4
4. Abdomen black, bronze, green, or if slightly blue then with abundant yellow pubescence 5
   Abdomen distinctly metallic blue with black pubescence 9
5. Abdomen with abundant yellow pubescence at least on the under side, and conspicuously stencilled with yellowish tomentum; legs yellowish red; if ♀ then *stygis* Fabr. but if ♂ see 6
   Yellow pubescence never present on abdomen, legs entirely blackish.. .. 7

* Patton, Philippine Journal of Science, xxvii., 1925, pp. 397-401.

6. Male with facets of eyes of two distinct sizes ; eyes contiguous .. *stygia* Fabr.
Male with eyes well separated, facets all small .. .. *stygia ab. hilli* Patton.

7. Abdomen conspicuously stencilled with yellow tomentum .. *tibialis* Macq.
Abdomen not so marked ; tomentum, if present, very inconspicuous and silvery white 8

8. Abdomen metallic green .. .. *clausa* Macq.
Abdomen bronze, with conspicuous red tinge .. .. ? Sp.

9. Squamæ entirely china-white .. .. *dispar* Macq.
Squamæ black, white only at edges .. .. .. *erythrocephala* Meig.

Besides *Calliphora tasmanensis* Macquart, which I have been unable to include in the above key, the identities of the following species are yet to be ascertained :—

Somomyia melanifera Bigot.

Pollenia mortonensis Macquart.

Calliphora pusilla Macquart.

Pollenia viridiventris Macquart (type not found by Patton).

Neopollenia papua Taylor (recorded in Proc. Lin. Soc. N. S. Wales xlv., 1920, 203, and attributed to Walker).

Any of these may or may not belong to the genus *Calliphora*.

Gen. ? **calliphoroides** Johnston and Hardy (name attributed to Walker).

This strikingly handsome yellow species with metallic blue markings—the design consists of the golden thorax of three short uniform parallel stripes joined at the apex by a similar transverse bar, and on the abdomen transverse bands of blue alternating with yellowish white ones—was referred to in the original list and does not conform to the genus *Calliphora* as defined by Patton, nor is it a *Chrydomyia*. It is a Calliphorine, however, with contiguous eyes and bare squamæ. The latter character suggests *Lucilia*, under which genus Patton has described another yellow species from Australia ; the chætotaxy does not quite conform to *Lucilia*.

Calliphora hyalipennis Macquart.

Ochromyia Macquart, *Neocalliphora* J. & H. Tasmania, 18 females.

Of the specimens referred to under this name, one is from Eaglehawk Neck, April 1916, one from Mt. Wellington, January 1918, and sixteen from Strahan (People's Park), February 1924. Apparently it is a rare species on the eastern side of the island and breeds more abundantly in the dense scrubs of the western side.

This form is not to be confused with the well-known mainland form hitherto called *ochracea*, and which Patton states is a synonym of *hyalipennis*. The difference between the two is most readily distinguished by the tomentum of the thorax and front. In *ochracea* practically the whole of the otherwise black dorsal area of the thorax is covered by a yellowish tomentum giving that well-known yellow appearance, whilst in *hyalipennis* the whole of this area is black, blue-black in certain lights ; the tomentum is inconspicuous and of a silvery-white colour, similar to that on, say, *C. erythrocephala*, and does not interfere with the general blue-black appearance of the thorax.

Macquart states, "Thorax d'un noir bleuatre ; cotes et ecusson fauves," which exactly fits this species, as he makes no mention of yellow tomentum and moreover attributes the species to "Tasmanie." Schiner, on the other hand, in describing *ochracea*, leaves me a bit doubtful upon this subject, and Patton, in placing Schiner's name as a synonym of *hyalipennis*, naturally raises the question as to whether the locality for *ochracea* is an error, or is the Tasmanian reference itself an error and the description faulty. If Patton is right about the synonymy, then either the Australian or the Tasmanian form will need a new name. Surcoef's subsequent description reads more like a combination with the mainland species.

Dr. Ferguson informs me that Macquart used the name *Ochromyia hyalipennis* twice, once in 1834 for a species now known as *Palpostoma testacea*, and again in 1850 for the species here referred to ; in consequence the name is preoccupied. It is advisable to await further information regarding the identity of the type, as it is possible that the mainland species needs the new name, whilst this would appropriate that of *ochracea*.

Calliphora ochracea Schiner.

Neocalliphora (Brauer & Bergenstamm) J. & H. New South Wales and Queensland. A long series of both sexes.

Until such time as this and the above species have been satisfactorily identified, it seems advisable to retain the name *C. ochracea* hitherto used for the species. It differs from *C. hyalipennis* mainly by having the thorax almost entirely covered by yellowish tomentum and the abdomen is not a rich chestnut-brown that occurs on all but one of the Tasmanian specimens. It is significant to note that Patton in one place refers to "reddish brown" and in another "golden yellow" when referring to *hyalipennis*. The species is, I think, widely distributed over Australia, but no one has succeeded in breeding it. Like *C. hyalipennis* it is most abundant in the dense scrub-lands.

Calliphora augur Fabricius.

Musca Fabricius, *Anastellorhina* Cleland. Synonymy : *oceaniæ* Desvoidy, *lateralis* Macquart, ? *rufiventris* Macquart, *dorsalis* Walker, to which Patton adds *dichromata* Bigot, *xanthurea* Bigot, and *selasoma* Erichson. Victoria, South Australia and Queensland ; it also occurs in Tasmania and New South Wales. A long series of both sexes.

Patton was unable to find the type of *rufiventris* Macquart, but I have reason to believe that it is still in existence and possibly allied to *Anastellorhina bicolor*. Patten referred the last-named to this position, but in view of the probable elucidation of its identity by Dr. Aldrich it is advisable not to accept this determination. Doubtless there has been some confusion concerning the type, and it may be pertinent to remark that Macquart's description "Abdomine fulvo, incisuralis nigro anguste marginatis, latius in medio" does not conform to the abdomen of *C. augur* but might be applicable to that of some *C. stygia*, whilst the remainder of the description prohibits its being mistaken for any other *Calliphora*.

Calliphora stygia Fabricius.

Musca Fabricius, *Neopollenia* Brauer, *Anastellorhina* J. & H. Synonymy: *villosa* Desvoidy, *australis* Boisduval, *rufipes* Macquart, *ruficornis* Macquart, *lœmica* Walker.

Male aberration, *hilli* Patton.

Tasmania, Victoria, South Australia, Western Australia, New South Wales, and Queensland. A long series of both sexes, including the aberrant male from Tasmania, New South Wales, and Queensland.

In the original synonymic list, under the name *stygia* were included two forms of the male, one with the facets of the eyes everywhere small (*hilli*), and the other with these conspicuously larger on the upper half of the eyes. The line dividing these sizes in the latter case is fairly distinct—that is, the transition from the smaller to the larger is rather abrupt. On the form having the eyes with all facets small the front is conspicuous and rather wide, whilst on that having the enlarged facets the eyes encroach upon the front and become contiguous. The latter form is the more abundant, whilst the former has been given the specific name *hilli* by Patton, who was under the impression that it represented a distinct species.

Both forms are to be bred in Brisbane under conditions that point to the progeny being from the same parent, but the species does not breed at all readily here, so I have not been able to ratify or refute this opinion by breeding the complete progeny of undoubtedly one parent.

Dr. Ferguson informs me that he considers *Pollenia ruficornis* Macquart, judging from the description, is possibly *C. tibialis*. Macquart described the male in 1847 and the female in 1850; it is the latter description that specially suggests the relationship, the first description being unsatisfactory in this respect. Patton makes no mention of the form.

Calliphora rufipes Macquart, given by Patton as a synonym, is presumably the species described by Macquart as *Pollenia rufipes* (I do not know *Lucilia rufipes* used by Patton presumably for the same, in error), whilst that species described by Macquart as *Calliphora rufipes* is referred to by Patton on page 401 as being "probably the South African species *segmentaria*."

Calliphora tibialis Fabricius.

Musca Fabricius, *Anastellorhina* J. &. H. Tasmania, Victoria, and South Australia; a long series of both sexes. Queensland, 1 ♂.

For a long time I suspected this species would prove another variety of *C. stygia*, but not till I had searched for and taken it myself was I convinced otherwise. It has distinctive habits that are significant.

C. stygia, in Tasmania at least, occurs on bushes and low herbage and if disturbed from the ground invariably rises, whilst *C. tibialis* keeps close to the ground. Every specimen caught well above the ground proves to be *C. stygia*, whilst those caught resting on or flying just above the ground nearly always were *C. tibialis*. After discovering this habit, I again sought for the species in Queensland but without success. The only Queensland specimen seen by me was taken by Master Lewis Pottenger at Sunnybank, Brisbane, during October 1925, and was handed to me alive.

Professor Johnston informs me that *C. tibialis* occurs very abundantly around Adelaide, especially in certain kinds of hedges, and whilst *stygia* readily invades houses *tibialis* does not do so.

Calliphora tasmanensis Macquart.

Pollenia Macquart. Not recognised in my collection but Patton considers it a good species.

Calliphora clausa Macquart.

Tasmania, 5 males and 2 females.

Patton mentions that *C. clausa* Macquart was not found by him and he suggests deleting the name. Not only is this procedure inadvisable till all sources whereby the species might be determined are exhausted, but in this case I believe I have it represented from Hobart, Mt. Wellington, and Zeehan.

Calliphora sp.

Tasmania, 2 males and 4 females from Zeehan.

Calliphora dispar Macquart.

Synonymy :—*pubescens* Macquart, Johnston and Hardy ; *ruficornis* Walker ; ? *tessellata* Macquart. Tasmania and Queensland, 2 males and 4 females.

Calliphora erythrocephala Meigen.

Tasmania, Victoria, South Australia, and New South Wales (introduced), 5 males and 5 females.

The Royal Society of Queensland.

Report of Council for 1924.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its Report for the year 1924.

During the year twelve papers were read and discussed before the Society and published. The following lectures, which were well attended and to which the public was invited, were delivered:—"The Occurrence of Petroleum," by Dr. Arthur Wade, Adviser on Petroleum to the Commonwealth Government; and "Geological Aeronautics," by Mr. B. Dunstan, Chief Government Geologist of Queensland.

Under the new arrangement granted in 1923, the cost of printing the Proceedings of the Society has this year been subsidised by the Government of Queensland to the extent of £129, as compared with a £50 grant in previous years. The Council, in acknowledging this generous subsidy, wishes to express its grateful appreciation of the practical assistance which was thus afforded. Appreciative acknowledgment is also made to the University of Queensland for a substantial subsidy towards the printing of a paper by Professor H. C. Richards, D.Sc., and Mr. W. H. Bryan, M.Sc., entitled "The Geology of the Silverwood–Lucky Valley Area," and to the Queensland Irrigation Commission for the offer of financial assistance in the production of the coloured and other plates illustrating Mr. P. C. Tibbits' paper entitled "The Artesian Waters of Queensland."

During the year the housing of the Society's valuable library has been considerably improved by the erection of a new set of shelves and the (as yet incomplete) rearrangement of the books in a more readily accessible manner, as a result of the voluntary efforts of several members of the Council.

The membership roll consists of 142 ordinary members (as compared with 91 in the previous year), nine corresponding members, and seven life members. During the year four members resigned and 52 new members were elected.

This marked increase in the membership of the Society, while it doubtless represents in part the natural and unaided growth which is to be expected in such an institution, is in greater part the result of the distribution among suitable persons of a circular drawn up by a Special Committee of the Council, which described the work of the Society and pointed out its benefit to the community.

The Council reports with deep regret the death, during the year, of two members of the Society, namely Mr. R. Gailey and Mr. L. E. Cooling.

There were ten meetings of the Council. The attendance was as follows:—E. W. Bick 9, W. H. Bryan 9, J. V. Duhig 3, W. D. Francis 8, E. J. Goddard 4, E. H. Gurney 9, R. W. Hawken 6, H. A. Longman 9, E. O. Marks 10, H. J. Priestley 5, H. C. Richards 8, C. T. White 10.

In August the triennial meeting of the Australasian Association for the Advancement of Science was held in Adelaide. Professor Richards, who represented this Society at the meeting and who was elected president of Section C, reported the results of the A.A.A.S. meeting to a meeting of this Society on his return, and accompanied his report with an interesting account of excursions in the Mallee district of Victoria and in South Australia.

W. H. BRYAN, *President*.

W. D. FRANCIS, *Hon. Secretary*.

THE ROYAL SOCIETY OF QUEENSLAND.

STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDING 31ST DECEMBER, 1924.

Cr. | Dr.

RECEIPTS.	£	s.	d.
Bank Balance, 31st December, 1923	13	7	7
Subscriptions	152	0	0
Government Subsidy (Printing)	129	0	0
Extra Reprints and Blocks	38	13	4
Sale of Volumes	1	12	6
	£334	13	5

EXPENDITURE.	£	s.	d.
Government Printer—			
Volume and Abstracts	258	0	0
Stationery and Printing	8	10	9
Library Shelving	28	0	0
Hon. Secretary (Postages and Petty Cash)	12	0	0
Hon. Librarian (Postages and Petty Cash)	2	0	0
Hon. Treasurer (Postages and Petty Cash)	2	0	0
Advertising Lectures	4	15	0
Lanternists (Falk, £2 10s.; Illidge, 10s.)	3	0	0
Insurance, State Government	0	14	5
Bank Charges	0	10	0
Cheque Book	0	2	6
Exchanges	0	7	1
Cheque 384 not Paid on 31st December, 1923	2	0	0
Balance on Hand (in Bank)	12	13	8
	£334	13	5

Examined and found correct.
H. J. PRIESTLEY,
Hon. Auditor, 10th March, 1925.

E. W. BICK, Hon. Treasurer.

The Annual Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th March, 1925.

The Deputy Governor, the Hon. W. Lennon, presided.

The minutes of the previous Annual Meeting were read and confirmed.

On the motion of Mr. R. A. Wearne, B.A., seconded by Mr. L. C. Ball, B.E., the Annual Report of the Council and the Financial Statement were received and adopted.

The following officers were elected for 1925 :—

Patron : His Excellency Sir Matthew Nathan, P.C., G.C.M.G.

President : Professor R. W. H. Hawken, B.A., M.E., M.Inst.C.E.

Vice-Presidents : Mr. W. H. Bryan, M.Sc. (*ex officio*), and Dr. J. V. Duhig, M.B.

Hon. Secretary : Mr. W. D. Francis.

Hon. Treasurer : Mr. E. W. Bick.

Hon. Editor : Mr. H. A. Longman, F.L.S.

Hon. Librarian : Mr. D. A. Herbert, M.Sc.

Hon. Auditor : Professor H. J. Priestley, M.A.

Members of the Council : Professor E. J. Goddard, B.A., D.Sc.; Dr. E. O. Marks, B.A., B.E., M.D.; Professor H. J. Priestley, M.A., Professor H. C. Richards, D.Sc., and Mr. C. T. White, F.L.S.

Dr. F. C. Turnbull, M.R.C.S. Eng., L.R.C.P. Lond., Messrs. A. N. Falk, R. H. Buzacott, G. H. Beckmann, B.Sc., V. Grenning, R. C. Mundell, B.Sc., A. E. Harding Frew, B.E., and J. R. Kemp were nominated for ordinary membership.

Hon. A. J. Jones and Messrs. F. C. Ford and L. Fortescue were unanimously elected Ordinary Members.

Professor Hawken, who was inducted to the position of President of the Society for 1925, thanked the meeting for his election.

The Retiring President, Mr. W. H. Bryan, M.Sc., delivered his address entitled " A Critical Revision of the Data concerning Earth Movements in Queensland." The data bearing on earth movements in Queensland are collected, placed upon maps, and analysed with the object of determining the age of each of the movements. Consideration is given to the areal distribution and intensity of each movement, the possibility of the assignment of the movements to one fundamental scheme, the possibility of such scheme being rhythmical, and the relationship between earth movements and igneous activity. Several hypotheses concerning the structural geology of Queensland are advanced.

On the motion of Professor Richards, seconded by Dr. E. O. Marks, a vote of thanks was accorded the Retiring President for his address.

A vote of thanks, which was proposed by the President (Professor Hawken) and carried by acclamation, was tendered to the Hon. W. Lennon for presiding.

ABSTRACT OF PROCEEDINGS, 27TH APRIL, 1925.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 27th April, 1925.

The minutes of the previous Monthly Meeting were read and confirmed.

Messrs. B. E. Shaw, A.M.I.E., C. Ogilvie, B.E., A. F. Sharp, B.E., and H. M. Sherrard, M.C.E., were nominated for ordinary membership, and Mr. A. K. Denmead as an associate of the Society.

Dr. F. C. Turnbull, M.R.C.S., L.R.C.P., and Messrs. A. N. Falk, R. H. Buzacott, G. H. Beckmann, B.Sc., V. Grenning, R. C. Mundell, B.Sc., A. E. Harding Frew, B.E., and J. R. Kemp were unanimously elected as ordinary members.

Mr. H. A. Longman, F.L.S., exhibited (1) a specimen of *Liasis childreni,* being one of two caught at "The Gap," near Brisbane, and presented to the Queensland Museum by Mr. F. Smith; the occurrence of this snake so far south was of interest; (2) a specimen of *Crocodilus johnsoni,* 295 mm. in length, which had been captured in the Wickham River, off Victoria River, Northern Territory, and forwarded by Mrs. T. Graham; the snout in this juvenile crocodile was relatively short.

Dr. E. O. Marks, B.A., B.E., exhibited specimens of rhyolite, which he collected at Point Lookout, Stradbroke Island. He stated that there were three rocky areas on Stradbroke and Moreton Islands, and it was an interesting fact that the rock at Point Lookout differed fundamentally from the Dunwich and Cape Moreton rocks, which were regarded as stratified rocks of Mesozoic age.

Messrs. F. Bennett, G. H. Jorgensen, Chas. Hedley, W. H. Bryan, and Dr. E. O. Marks took part in the discussion on the exhibits.

Mr. W. H. Bryan, M.Sc., communicated a paper by Dr. H. I. Jensen entitled "The Granites of Croydon and the Supposed Intrusive Bar." As the result of field investigations and detailed petrographical work on rock-sections, the author concluded—(1) That the granites of Croydon are true granites and not metamorphosed sediments as maintained by Rands, and that they have been lowered into the zone of partial recrystallisation at some period of their history; and (2) that the limits of the auriferous portion of the Croydon Goldfield were not determined by the presence of a supposed "intrusive bar."

Mr. F. B. Smith, B.Sc., F.I.C., read two papers by Mr. T. G. H. Jones, B.Sc., A.A.C.I., and himself, entitled "Elemi—the Oleo-Resin of *Canarium Muelleri,*" and "The Essential Oils of Australian Menthas —I. *Mentha satureioides.*" The principal constituent of the oleo-resin of *Canarium Muelleri* was found to be pinene, which was accompanied by dipentene, phellandrene, and terpineol. The resin consisted chiefly of two amorphous solid alcoholic bodies isomeric with the crystalline amyrins of elemi resins elsewhere described. The principal constituent of the Mentha oil was found to be pulegone, which was accompanied by menthol and minor substances. Messrs. C. T. White, F. Bennett, and W. D. Francis took part in the discussion on the papers.

On the motion of Mr. H. A. Longman, the President (Professor R. W. H. Hawken) was congratulated upon his appointment as chairman of the Cross-River Commission.

On the motion of Mr. C. T. White, Mr. Chas. Hedley, F.L.S., was congratulated upon the award of the Clarke Memorial Medal, which was bestowed upon him by the Royal Society of New South Wales for his meritorious contributions to the natural history of Australia.

Abstract of Proceedings, 20th May, 1925.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Wednesday, 20th May, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The minutes of the previous meeting were taken as read.

Dr. J. B. McLean, Mr. R. J. Lydon, and Rev. N. Michael were nominated for ordinary membership, and Misses N. Harris and R. Phillips were nominated as associates.

Messrs. B. E. Shaw, A.M.I.E., C. Ogilvie, B.E., A. F. Sharp, B.E., and H. M. Sherrard, M.C.E., were unanimously elected as ordinary members, and Mr A. K. Denmead was unanimously elected as an associate.

Mr. Chas. Hedley, F.L.S., delivered a lecture entitled "A Naturalist in Central Africa." Some features of the Great Rift Valley, Mount Kilimandjaro, Lake Tanganyika, and the surrounding country were described and illustrated by lantern slides. A vote of thanks to the lecturer was moved by Captain G. H. Wilkins (visitor), seconded by Dr. Cumbrae-Stewart, and carried by acclamation.

Abstract of Proceedings, 29th June, 1925.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 29th June, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. A. F. Partridge was nominated for ordinary membership.

Dr. J. B. McLean, Mr. R. J. Lydon, and Rev. N. Michael were unanimously elected as ordinary members, and Misses N. Harris and R. Phillips as associates.

Mr. H. A. Longman, F.L.S., exhibited (1) specimens representing a series of twenty-three eggs found in the oviduct of a brown snake, *Demansia textilis*, from the Toowoomba district; (2) a cast of the type of *Hesperopithecus haroldcookii*, from the Snake Creek Beds, Nebraska, described by Henry Fairfield Osborn as "the first anthropoid primate found in America"; the cast was compared with the third upper molars of Australian aborigines, and the exhibitor stated that in dimensions and contours *Hesperopithecus* came within the range of variation found in megadont molars with divergent roots in the Queensland Museum.

Mr. Chas. Hedley, F.L.S., exhibited a fossil Astrean coral from Darnley Island, Torres Straits. Much coral is scattered through the wall of a large ash crater at Treacherous Bay. This has evidently come from a bed beneath the Island and has been torn out of the throat of the volcano. Most of the coral has been so altered by heat that organic structure has disappeared. In one large block the core had resisted sufficiently to preserve details of the corallia. A piece of this furnished the exhibit, which was collected by Mr. Hedley in October, 1924.

Mr. C. T. White, F.L.S., exhibited a seedling of the Milky Plum, *Amorphospermum antilogum*, showing the method of germination in this species.

Mr. W. D. Francis read a paper entitled "A Contribution to the Theory of the Relationship of Iron to the Origin of Life." The original theory connecting iron with the origin of life was published by Moore and Webster in the Proceedings of the Royal Society, London (B. vol. 87, 163 and 556, 1913, 1914). The present contribution to it is based upon the following inorganic properties of iron or its compounds: (1) The oxidation of ferrous compounds and of native iron, which is analogous to physiological respiration; (2) the chemical affinities of iron for the common protein and carbohydrate elements and the combination of water and the fixation of carbon dioxide and ammonia by iron undergoing the rusting process; (3) the representation of or very close approximation to the colloid state by iron rust. Prof. Goddard, Dr. Duhig, Messrs. Herbert and Longman, and Dr. Turner took part in the subsequent discussion.

Abstract of Proceedings, 27th July, 1925.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 27th July, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. A. F. Partridge was unanimously elected as an ordinary member.

Prof. H. C. Richards, D.Sc., and Mr. W. H. Bryan, M.Sc., exhibited:

A. Specimens of Brisbane tuff (commercially known as "porphyry"), collected by the exhibitors from Castra, about 12 miles east-south-east of Brisbane. The interest of the exhibits was threefold: 1. They were from a new locality, being considerably east of any previously known outcrops, and measuring 30 feet in thickness. 2. The basal portions contained large angular and sub-angular blocks of rhyolite. 3. Some portions of the tuff contain numerous flattened spherical bodies of varying size but averaging about ½ inch in greatest diameter, and showing when broken a regularly concentric structure.

B. Specimens of the corals *Koninckophyllum inopinatum* Eth. fil., *Lithostrotion* (?) *columnare* Eth. fil., and *Syringopora syrinx* Eth. fil. from the Carboniferous limestone of Lion Creek, Stanwell.

C. Specimens of *Favosites* sp. and *Heliolites* sp. from the limestone quarry at Marmor. *Favosites* sp. had been previously collected by Mr. H. A. Longman from this locality, but is here recorded for the first time, while this constitutes the first record of *Heliolites*. The presence of these two genera fixes the age of the Marmor limestone as at least as old as Devonian, and removes the possibility supported by some geologists of its being Carboniferous.

Mr. H. A. Longman, F.L.S., exhibited (1) fragments (mainly alveolar) of fossil molars forwarded by Mr. R. S. Philp, through Prof. Richards, which had been found in a well at Castle Creek, Q., at a depth of 40 feet. These Pleistocene fossils probably represented a new species of *Palorchestes*. (2) A "Liangle" or aboriginal wooden battle-axe with a mucronate tip to the broad end, and carved with figures of snakes, birds, a lizard, and a frog. This elaborate specimen was obtained by Mr. H. A. Craig at Thargomindah, and presented to the Queensland Museum by Sir Matthew Nathan.

Mr. C. T. White, F.L.S., exhibited: (A) Specimens of *Agonis abnormis* (F.v.M.), White and Francis, from trees growing in fair abundance along a small creek at Castra, about 12 miles from Brisbane. The species had not been collected previously in the neighbourhood of Brisbane. (B) Specimens of *Verbesina encelioides,* B. & Hook, f., a sunflower-like plant, a native of North America, which during the past few years has proved to be a troublesome pest in several parts of Southern Queensland.

Mr. W. H. Bryan, M.C., M.Sc., read a paper by himself and Mr. C. H. Massey, entitled "The Geological Range of the Tiaro Series." As a result of their recent field work in the type district, the authors pointed out that the Tiaro series, as at present defined, is there naturally divisible into four series, which they suggested should be called the Graham's Creek Series, the Tiaro Series (in a restricted sense, but including the coal measures), the Myrtle Creek Series, and the Brooweena Series. Prof. Richards, Dr. E. O. Marks, and the President took part in the discussion on the paper.

Abstract of Proceedings, 31st August, 1925.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 31st August, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

Messrs. E. J. Ferguson Wood and N. L. Kelly were nominated as associates.

Mr. C. T. White, F.L.S., exhibited specimens of *Bursaria incana* Lindl. showing variation in foliage.

Mr. H. A. Longman, F.L.S., exhibited specimens of the "Magnificent Spider," *Dicrostichus magnificus*, artificially liberated from a cocoon in which the sexes were distinctly differentiated. The bulbous sexual appendages of the males could be distinguished by the naked eye. In the females the abdomen is larger and is more prominently marked with greenish-yellow spots and the cephalo-thorax is not nearly so dark as in the males. In these spiderlings there is no sign of the two prominent supero-lateral tubercles of the adult. The exhibitor stated that these tiny spiderlings, after ballooning, hid on the underside of leaves, and although they were unable to spin a web they caught tiny moths.

Messrs. F. Bennett and D. A. Herbert discussed the exhibits.

Mr. D. A. Herbert, M.Sc., read a paper entitled "Movement of *Mimosa pudica* as affected by Anæsthetics and Other Substances." The author points out that the term anæsthesia implies a suspension of sensitivity, and in this respect cannot be applied to the action of anæsthetics on *Mimosa pudica*, the power of movement being lost only when the plant is permanently injured. The effect of lipoid solvents on movement was shown to be similar to that of such anæsthetics as ether and chloroform, but enzyme poisons destroyed the power of response only after prolonged treatment. Alcohol, a mild anæsthetic, prevents movement by coagulation of protoplasm. Incidental to the main topic, new facts concerning the nature of conduction and of response are reported. The President, Drs. E. O. Marks and J. V. Duhig, and Messrs. C. T. White, H. A. Longman, F. Bennett, and W. D. Francis took part in the discussion on the paper.

Abstract of Proceedings, 28th September, 1925.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 28th September, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Messrs. E. J. Ferguson Wood and N. L. Kelly were unanimously elected as Associates.

On the motion of Mr. Chas. Hedley, seconded by Prof. H. C. Richards, it was decided to ask the Government to reserve for scenic purposes some of the areas of rain forest adjoining the railway between Cairns and Cardwell. It was suggested that the Society might seek the support of the Queensland Naturalists' Club and other interested institutions in furthering the object of the motion.

Prof. H. C. Richards exhibited a meteorite found about 80 miles from Boulia, Western Queensland, and forwarded to him by the Shire Clerk of Boulia. It is composed chiefly of coarsely crystalline iron which indicated slow cooling under great pressure.

A paper by Dr. H. I. Jensen entitled "Geological Features of the Mandated Territory of New Guinea" was read by the Hon. Secretary in the absence of the author. The paper places on record some of the essential facts of the geology of the Mandated Territory and adjacent islands. The author states that he is in agreement with Rev. C. H. Massey in his general contention that the islands of New Guinea form the remains of a broken up continent. Dr. Jensen concludes that up to the Cretaceous period New Guinea, the surrounding islands, the Coral Sea, and possibly New Caledonia formed a continental mass continuous with North Queensland and Central Australia. Prof. Richards, Dr. Whitehouse, Messrs. Owen Jones, D. Herbert, C. T. White, F. Bennett, and Prof. Goddard took part in the discussion on the paper.

Mr. C. T. White read a paper by himself and Mr. W. D. Francis entitled "Contributions to the Queensland Flora, No. 3." The following new species are described and figured:—*Polycarpæa glabra*, *Melicope stipitata*, *Elæodendron microcarpum*, *Cassia neurophylla*, *Polyosma rhytophloia*, *Xanthostemon Youngii*, *Sideroxylon singuliflorum*, *Prostanthera megacalyx*, *P. suborbicularis*, *Cryptocarya corrugata*, and *Grevillea sessilis*. In addition, the paper contains descriptions of two new varieties, records of fourteen species not previously known as Queensland plants, descriptions of flowers or fruit of species of which only fruit or flowers were previously described, and definite locality records of a number of rare native plants. Prof. Goddard and Messrs. Bennett and Herbert took part in the subsequent discussion.

ABSTRACT OF PROCEEDINGS, 26TH OCTOBER, 1925.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 26th October, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The meeting, to which the public was invited, was devoted to the celebration of Huxley's Centenary. The following addresses were given:—

Huxley: Personal Characteristics, by Mr. Heber A. Longman;

Huxley: The Biologist, by Professor E. J. Goddard;

Huxley: The Educationalist, by Professor J. P. Lowson.

The various aspects of the life and work of Thomas Henry Huxley were dealt with in an interesting way by the three speakers, and the addresses were greatly appreciated by the large audience. The meeting terminated with a hearty vote of thanks to the speakers, which was moved by the President and carried with acclamation.

ABSTRACT OF PROCEEDINGS, 30TH NOVEMBER, 1925.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th November, 1925.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. F. F. Coleman was nominated for ordinary membership.

Mr. H. A. Longman exhibited (1) a series of geological specimens collected in the Galah Gorge, near Hughenden; (2) a fragment of a mandible of *Diprotodon australis* found in the Flinders River at Maxwelton, Central Queensland, collected by Mr. Rex W. Crane, and donated to the Queensland Museum, this being a new locality for this large marsupial.

Mr. J. H. Reid exhibited a small collection of marine fossils from the Permo-Carboniferous System of Central Queensland which he had collected and which was now being examined by Dr. F. W. Whitehouse. It included several genera, such as *Furcaster* and a considerable number of species not yet recorded from the Australian Permo-Carboniferous System. Among the latter is a *Productus* which forms a sub-genus of world-wide distribution and will probably have an important bearing on future correlation. The specimens were collected from the area between the Bowen River coalfield and the Dawson River, as well as from the Mackay District and Cracow Station on the Upper Dawson River.

Prof. H. C. Richards exhibited specimens of bottle glass from the sea shore at Scarborough, Queensland, showing slight corrosion and a fine incrustation of iridescent material similar in appearance to the nacreous layer of shells.

Dr. E. O. Marks discussed the exhibits.

Mr. G. H. Hardy, Walter and Eliza Hall Fellow in Economic Biology, read a paper entitled "Notes on Australian Flies of the Genus *Calliphora*." Mr. D. A. Herbert and Mr. E. Ballard took part in the discussion.

Publications have been received from the following Institutions, Societies, etc., and are hereby gratefully acknowledged.

AFRICA.

Durban Museum, Durban.
South African Museum, Capetown, South Africa.
Transvaal Museum, Pretoria, South Africa.
Geological Society of South Africa, Johannesburg.

AMERICA.

BRAZIL—
Instituto Oswaldo Cruz, Rio Janeiro.

CANADA—
Department of Mines, Ottawa.
Royal Canadian Institute, Toronto.
Royal Astronomical Society of Canada, Toronto.
Royal Society of Canada, Ottawa.

UNITED STATES—
American Academy of Arts and Sciences, Boston.
American Geographical Society, New York.
National Academy of Science, Philadelphia.
American Philosophical Society, Philadelphia.
Californian Academy of Science, San Francisco.
Indiana Academy of Science.
Rochester Academy of Science.
National Academy of Science and Smithsonian Institute, Washington.
Library of Congress.
American Museum of Natural History, New York City
New York Zoological Society, New York.
Department of Agriculture.
Arnold Arboretum.
Department of Commerce, New York.
Missouri Botanic Gardens, St. Louis, Missouri.
University of California, Berkeley.
University of Colorado.
Cornell University.
John Hopkins University.
University of Illinois, Urbana.
Ohio State University.
University of Kansas, Lawrence.
University of Minnesota, Minneapolis.
Oberlin College.
National Research Council.
Buffalo Society of Natural Science.
Portland Society of Natural History.
Lloyd Library.
The University of Michigan, Michigan.
Bernice Pauahi Bishop Museum, Honolulu, Hawaiian Islands.
Ohio Academy of Science.
Bureau of Standards, Washington.
Puget Sound Biological Station, University of Washington, Seattle.

MEXICO—
Instituto Geologico de Mexico, Mexico.
Sociedad Cientifica, Mexico.
Observatorio Meteorologico Central, Tacaibaya D.F., Mexico.
Secretario de agricultura y fomento, Mexico.

ASIA.

CEYLON—
Colombo Museum, Colombo, Ceylon

INDIA—
Agricultural Institute, Pusa, Bengal.
Geological Survey of India.
Superintendent, Government Printing.
Survey of India, Dehra Dun.

JAPAN—
Imperial University, Kyoto.
Imperial University, Tokyo.

JAVA—
Department van Landbrouw, Batavia.
Koninckylke Naturkundige, Batavia.

PHILIPPINE ISLANDS—
Bureau of Science, Manila.

AUSTRALIA AND NEW ZEALAND.

QUEENSLAND—
Field Naturalists' Club, Brisbane.
Geological Survey of Queensland, Brisbane.
Queensland Museum, Brisbane.
Government Statistician, Brisbane.
Royal Geographical Society of Australasia (Queensland), Brisbane.

NEW SOUTH WALES—
Australasian Association for the Advancement of Science, Sydney.
Department of Agriculture, N.S.W.
Botanic Gardens, Sydney.
Geological Survey of N.S.W., Sydney.
Public Library, Sydney.
Linnean Society of N.S.W., Sydney.
Australian Museum, Sydney.
Royal Society of New South Wales, Sydney.
Naturalists' Society of N.S.W., Sydney.
University of Sydney.

Victoria—

Bureau of Census and Statistics, Melbourne.
Royal Society of Victoria, Melbourne.
Field Naturalists' Club, Melbourne.
Department of Agriculture, Melbourne.
Department of Mines, Melbourne.
Australasian Institute of Mining and Metallurgy, Melbourne.
National Museum, Melbourne.
Institute of Science and Industry, Melb.
Commonwealth Department of Health, Melb.

Tasmania—

Royal Society of Tasmania, Hobart.
Field Naturalists' Club, Hobart, Tasmania.
Geological Survey of Tasmania.

South Australia—

Royal Society of South Australia, Adelaide.
Royal Geographical Society of S.A., Adel.
National Museum of South Australia, Adel.
Geological Survey of S. Australia, Adel.
Public Library, Museum, and Art Gallery, Adel.

Western Australia—

Royal Society of Western Australia, Perth.
Geological Survey of W. Australia, Perth.

New Zealand—

Auckland Institute, Auckland.
New Zealand Board of Science and Art.
Dominion Laboratory, Wellington.
Geological Survey of New Zealand.
New Zealand Institute, Wellington.
Dominion Museum, Wellington.

EUROPE.

Austria—

Annals Natural History Museum, Vienna.

Belgium—

Academie Royale, Brussels.
Société Royale de Botanique de Belgique.
Société Royale de Zoologique de Belgique.

Czecho-Slovakia—

Spolecnosti Entomologické, Prague.
Plant Physiological Laboratory, Charles University, Prague.

Denmark—

The University, Copenhagen.

France—

Société Geologique et Mineralogique de Bretagne, Rennes.
Société Botanique de France, Paris.
Musee d'Histoire Naturelle, Paris.
Société Scientifique Naturelle, Nantes.
Office Scientifique Pêches Maritimes.
Observations Meteorologique de Mont Blanc.

Germany—

Naturwissenschaftlichen Verein, Bremen.
Bibliothek der Bayer, Akademie der Wissenschaften, Munich.
Notgemeinschaft der Deutschen Wissenschaft, Berlin.
Senckenbergischen Bibliothek, Frankfurt, A.M.
Naturhistorischer Verein der preus Rheinland und Westfalens, Bonn.
Sachs Akademie der Wissenschaften, Leipzig.
Deutsche Geologische Gesellschaft, Berlin.
Zoologischen Staatsinstitut und Zoologischen Museum, Hamburg.
Gesellschaft für Erdkunde, Berlin.
Centralblatt für Bakteriologie, Parasitenkunde und Infectionskrankheiten.
Just's Botanisches Jahrbucher.

Great Britain—

Cambridge Philosophical Society.
Conchological Society of Great Britain and Ireland.
Imperial Bureau of Entomology, London.
Literary and Philosophic Society, Manchester.
Royal Society of London.
Royal Botanic Gardens, Kew.
Royal Colonial Institute, London.
Royal Society of Edinburgh.
Botanic Society, Edinburgh.
Royal Irish Academy.
British Museum (Natural History).
Royal Dublin Society.

Italy—

Societa Agricana d'Italia, Naples.
Instituto di Bologna.
Societa Toscana di Scienze Naturali, Pisa.
Museo Civico, Genova.

Poland—

Universitatis liberæ Polonæ.

Spain—

Real Academia de Ciencias de Madrid.
Real Academia de Ciencias de Barcelona.
Academia de Ciencias de Zaragoza.

Sweden—

Geological Institute, Upsala.

Switzerland—

Naturforschende Gesellschaft, Basle.
Naturforschende Gesellschaft, Zurich.
Société de Physique et d'Histoire Naturelle, Geneva.
International Labour Office, Geneva.

List of Members.

Corresponding Members.

‡Danes, Dr. J. V.	University, Prague, Czecho-Slovakia.
David, Professor, Sir T. W. E., F.R.S.	The University, Sydney, N.S.W.
‡Domin, Dr. K.	Czech University, Prague, Bohemia.
‡Hedley, C., F.L.S.	Barrier Reef Committee, Brisbane.
Liversidge, Prof. A., F.R.S.	"Fieldhead," Coombe Warren, Kingston Hill, Surrey, England.
‡Maitland, A. Gibb, F.G.S.	Geological Survey Office, Perth, W.A.
Rennie, Professor E. H.	The University, Adelaide, S.A.
‡Skeats, Professor E. W.	The University, Melbourne, Vic.

Ordinary Members, Etc.

Abercombie, Miss J. B.	Lapraik Street, Albion, Brisbane.
Alexander, W. B., M.A.	Prickly-pear Laboratory, Sherwood.
Allan, R. Marshall, M.D., F.R.C.S. (Edin).	Medical Society's Hall, Brunswick Street, East Melbourne.
Appleby, W. E.	Sugar Refinery, New Farm.
Bage, Miss F., M.Sc.	The Women's College, Kangaroo Point, Brisbane.
†Bagster, L. S., D.Sc.	The University, Brisbane.
‡†Bailey, J. F.	Botanic Gardens, Adelaide, S.A.
Ball, L. C., B.E.	Geological Survey Office, Brisbane.
Ballard, E., B.A.	Department of Agriculture and Stock, Brisbane.
‡†Bancroft, T. L., M.B.	Eidsvold, Queensland.
Barker, Miss E., B.A.	Girls' Central School, Maryborough.
Barton, E. C., A.M.I.C.E.	care of National Bank of Australasia, 4 Queen Victoria Street, London.
Beckman, G. H., B.Sc.	Crook Street, Northgate, Brisbane.
Berney, F. L.	Barcarolle, via Longreach.
‡Bennett, F., B.Sc.	State School, Toowong, Brisbane.
Bick, E. W.	Botanic Gardens, Brisbane.
Bond, G. G	The Observatory, Brisbane.
Broadbent, J. E.	Department of Justice, Brisbane.
Brown, Jas., B.A., M.B., Ch.B. (Edin.). D.P.H. (Cambridge)	"Widmoorene," Margaret Street, Toowoomba
‡Brunnich, J. C., F.I.C.	Agricultural Chemist's Laboratory, William Street, Brisbane
‡Bryan, W. H., M.Sc.	The University, Brisbane.
Brydon, Mrs.	Department of Public Instruction, Brisbane.
Buhot, E. W.	Department of Health, Brisbane
Bundock, C. W., B.A.	"Kooralbyn," Beaudesert.
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Buzacott, R. H.	Biology Department, The University, Brisbane.

† Life Members.

‡ Members who have contributed papers to the Society.

Cameron, Colonel, D. C., C.M.G., D.S.O., M.P.	Parliament of the Commonwealth, Melbourne.
Cameron, W. E., B.A.	Royal Societies' Club, St. James Street, London.
Carson-Cooling, Geo., M.Sc.	Boys' Grammar School, Brisbane.
Cayser, A. A., B.Sc.	The University, Brisbane.
Cilento, R. W., M.D., B.S.	Institute of Tropical Medicine, Townsville.
‡Colledge, W. R.	Friendly Societies' Dispensary, George Street, Brisbane.
Colvin, Joseph	George Street, Brisbane.
Cottrell-Dormer, W.	Sugar Experiment Station, Bundaberg.
Croll, Gifford, M.B.	Sherwood, Brisbane.
Cumbrae-Stewart, Professor F. W. S., D.C.L.	The University, Brisbane.
‡Denmead, A. K.	Men's Common Room, The University, Brisbane.
Dixon, G. P., C.B.E., M.B., Ch.M. ...	Wickham Terrace, Brisbane.
‡Dodd, Alan P.	Prickly-pear Laboratory, Sherwood, Brisbane.
Duhig, J. V., M.B.	"Edmonton," Wickham Terrace, Brisbane.
Duhig, Archbishop, D.D.	"Dara," Brisbane.
Dunstan, B.	Geological Survey Office, Brisbane.
Evans, C. K., M.Sc.	Ipswich Technical College, Ipswich.
Falk, A. N.	Geology Department, The University Brisbane.
Ford, F. Campbell	Surveyor-General's Office, Brisbane.
Fortescue, L.	New Zealand Chambers, 334 Queen Street, Brisbane.
‡Francis, W. D.	Botanic Gardens, Brisbane.
Freeman, C. B.	City Buildings, Edward Street, Brisbane.
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‡Hamlyn-Harris, R., D.Sc.	The Southport School, Southport.
Hardcastle, Mrs. T., B.Sc.	Jinbiggaree, near Dugandan.
Hardie, Sir David, M.D., M.S.	"Blythsdale," Hamilton, Brisbane.
‡Hardy, G. H.	Biology Department, The University, Brisbane.

† Life Members.

‡ Members who have contributed papers to the Society.

Harris, Miss N.	The University, Brisbane (Associate).
Harris, V. E. G., B.Sc.	The Southport School, Southport.
‡Hawken, Professor R. W., B.A., M.E., M.Inst. C.E.	The University, Brisbane.
‡Henderson, J. B., F.I.C.	Government Analyst, Brisbane.
‡Herbert, D. A., M.Sc.	Biology Department, The University, Brisbane.
Herdsman, L. P.	Government Printing Office, George Street, Brisbane.
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Jackson, J. H. S., M.B., B.S.	Kaewieng, New Guinea.
‡Jensen, H. I., D.Sc.	Treasury Chambers, George Street, Brisbane.
‡Johnston, Professor T. Harvey, M.A., D.Sc.	The University, Adelaide.
Jones, Hon. A. J.	Department of Mines, Brisbane.
Jones, Owen, B.Sc.	Camden House, Hamilton, Brisbane.
‡Jones, T. G. H., B.Sc., A.A.C.I.	Chemistry Department, The University, Brisbane
Jorgensen, G. H.	Lewis Street, Eagle Junction, Brisbane.
Just, J. S.	care City Electric Light Company, Boundary Street, Brisbane.
Kelly, N. L.	Biology Department, The University, Brisbane (Associate).
Kemp, J. R.	Main Roads' Board, Desmond Chambers, Adelaide Street, Brisbane.
Kerr, W. H., B.Sc.	"Kilmours," Edward Street, Toowong.
‡Lambert, C. A.	care of Bank of N.S.W., Melbourne, Vic.
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Lloyd, W.	Queensland Correspondence College, Adelaide Street, Brisbane.
‡Longman, H. A., F.L.S.	Queensland Museum, Brisbane.
‡Love, W., M.B., Ch.M.	1 Wickham Terrace, Brisbane.
Lowson, Professor J. P., M.A., M.D. ...	"Lauriston," Wickham Terrace, Brisbane.
Ludgate, Miss B., B.A.	Teachers' Training College, Brisbane.
Lydon, R. J.	Central Technical College, Brisbane.
‡Mackerras, Mrs. Ian, B.Sc.	"Beechworth," Stanton Road, Mosman, Sydney.
Marks, Hon. Dr.	101 Wickham Terrace, Brisbane.
Marks, A. H., C.B.E., D.S.O., M.D. ...	Wickham Terrace, Brisbane.
Marks, E. O., M.D., B.A., B.E.	101 Wickham Terrace, Brisbane.

† Life Members.

‡ Members who have contributed papers to the Society.

‡McCall, T,, F.I.C.	Government Analyst's Department, Brisbane.
McDonald, S. F., M.D., M.R.C.P.	"Fancourt," Wickham Terrace, Brisbane.
McDowall, Val., M.B.	Preston House, Queen Street, Brisbane.
McKenzie, A. D., M.B., Ch.M.	Russell Street, Toowoomba.
McLean, J. B., D.S.O., M.B., B.S.	General Hospital, Brisbane.
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PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

QUEENSLAND

FOR 1926.

VOL. XXXVIII.

ISSUED 10th FEBRUARY, 1927.

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The Royal Society of Queensland.

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VOLUME XXXVIII.

Vol. XXXVIII., No. 1.

Proceedings of the Royal Society of Queensland.

Presidential Address.

By Professor R. W. H. Hawken, B.A., M.E., M. Inst. C.E., M.I.E. Aust.

(Delivered before the Royal Society of Queensland, 29th March, 1926.)

Ladies and Gentlemen,—The report already submitted to you shows continued steady progress of the Royal Society of Queensland, and I would like to record here my appreciation of the keen spirit shown by the Council and officers. The several matters referred to sub-committees have been dealt with effectively, and generally an air of ordered efficiency has made the position of President as pleasant as it was honourable.

The continuous supply of good papers has been a most desirable feature of the year's activities and the attendance at meetings has been satisfactory, particularly to lectures of a semi-popular nature. This brings before us the question of rooms more suitable for members generally. The Royal Society exists for two purposes, one to encourage and record research in science, the other to interest and instruct the public in the aims and achievements of scientific work. For the latter purpose it is necessary to offer existing and potential members a central place for lectures and exhibits. Our present room is some distance from trams and trains and, especially in the evenings, it demands energetic enthusiasm on the part of those attending a meeting.

Your Council has considered the question of acting in conjunction with other societies of similar aims, but funds would not permit of any change at present. I commend the matter to the incoming President and Council to explore its possibilities.

It is my sad duty to mention the loss by death of five members of the Society during the year.

Mr. J. H. Maiden was an honorary member. His name is familiar in other countries as well as in Australia where his services to science, particularly to Botany, for forty years are recorded in his monumental volumes on Australian Flora. His ready assistance to fellow workers and his inspiring addresses and lectures will be treasured memories of a notable man.

Professor S. B. J. Skertchly, known to many of us by his racy articles on science, had a long career, forming a link with the great mid-Victorian personalities. For thirty-six years he resided in Queensland. He was first president of the Queensland Naturalists Club and a former president of the Queensland Royal Society and a member of various public bodies. His forte lay in showing that science is not necessarily dull, and he himself would have been the last to acknowledge that the scientist himself need be always solemn or even discreet.

Mr. Thomas Steel was a life member and the author of numerous papers published by the Linnean Society of New South Wales. He resided for thirty years in New South Wales and was only an occasional visitor to Brisbane.

Mrs. Lumley Hill had been a member of the Society for three years. Her membership of the Royal Society was part of a policy of using her extensive personal influence to advance the best interests of the community.

Mr. Douglas Ogilby was formerly a member. His papers on fishes are a valued portion of the Proceedings of the Society.

Mr. Kenneth Swanwick was held in affectionate regard by all who knew him. Always his actions were dictated by the idea of helping others.

The passing of those well known to us becomes endurable only because it is inevitable.

* * * * * *

THE LOCATION OF CITY BRIDGES.

(Plates I.-V., Text-figures 1-8, Tables I. and II.)

In what follows I will endeavour to traverse the rational or scientific principles to be applied to problems of "The Location of City Bridges," especially with reference to Brisbane, which furnishes a difficult example.

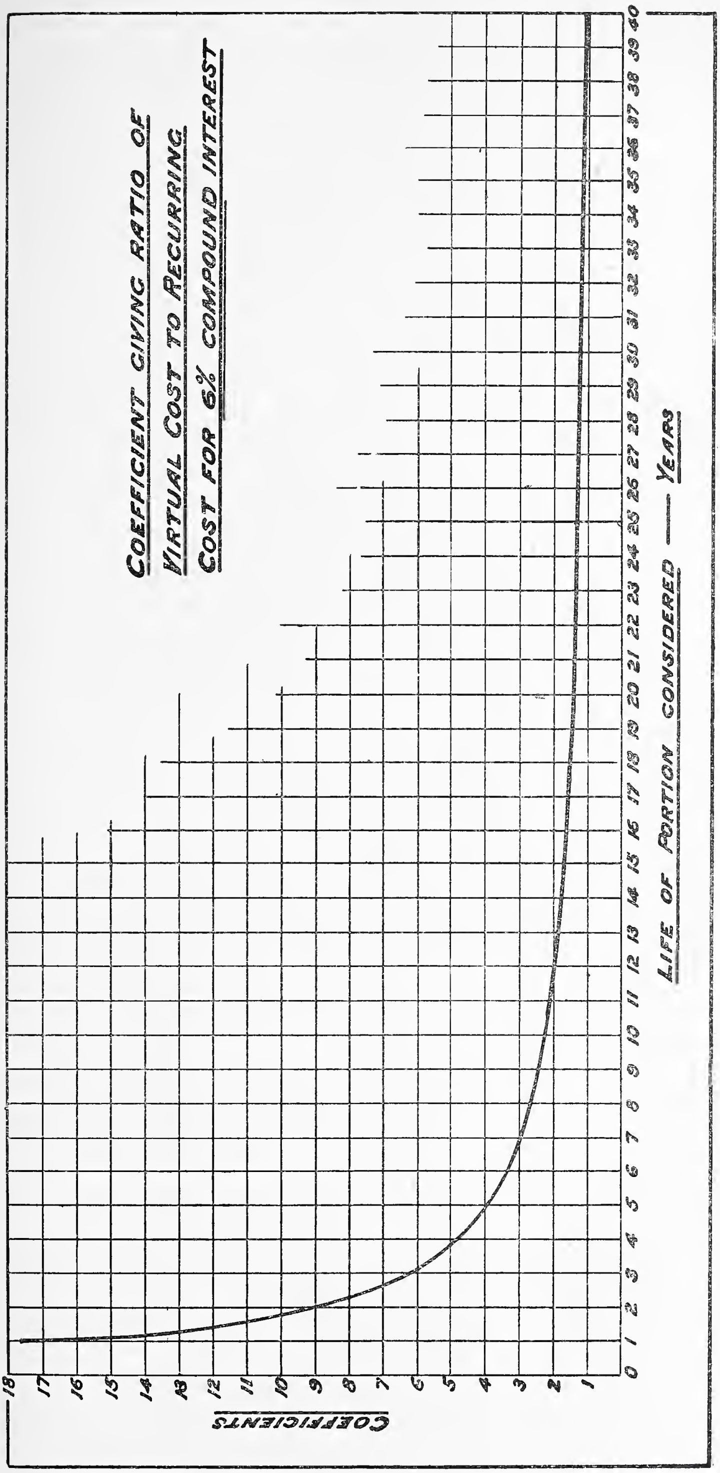
The problem is an engineering one in the broader sense—that is to say, the relative economies of various schemes have to be studied as well as the feasibility of each from a constructional point of view. The future must be visualised, yet present interests be conserved; convenience to all classes of expected traffic must be allowed for, and, not least, the æsthetic should be kept in mind. The results are to be finally embodied in one definite structure or, perhaps, more than one, as in the present case.

Such a set of conditions implies compromise and almost certain differences of opinion as to the conclusions arrived at, but I hope to show that the points of difference may be narrowed down, and in many cases eliminated.

Projects of this kind involve money, in this case millions of pounds. Money must be presumed to be always capable of earning interest. Compound interest is a schoolday nightmare gladly forgotten, but without some understanding of its results many of the comparative estimates to be given later would be vague and misleading.

I was fortunate in having simplified such computations* previously, and in expressing results graphically. It will be sufficient for our

* The details are expounded in a paper entitled "Economy of Purchase with Curves of Relative Cost," by the author, published by the Institution of Engineers, Australia, 1924.



Text-figure 1.

present purpose to explain the curve of Text-figure 1, which gives the multiplier of the first cost according to the number of years that a project or portion of such will last.

It is well known that each portion of a structure or project is subject to decay, so that it needs expenditure on "maintenance" and that wages and material are necessary to keep machinery running. Certain portions also have to be replaced after a time; again, a structure becomes worn out or obsolete. For our purpose we will assume such costs are recurring. For instance, maintenance and operation are reckoned annually; repainting of a bridge may be needed every five years, and steelwork may be assumed to last, or to have a life of, 40 years.

Suppose it were necessary to compare the relative costs of a ferry and of a bridge. Say the ferry costs £60,000, lasts 20 years, and has a charge of £8,000 per annum for maintenance, operation, and replacements, and that a bridge costs £200,000, lasts 40 years, and needs the expenditure of £5,000 every five years for replacements. Which is the cheaper, the ferry or the bridge? By the use of the curve shown we see that with money at 6 per cent.—

The Ferry has a virtual cost of £60,000 × 1·5 =	90,000
8,000 × 16·7 =	133,600
	£223,600
or its total annual cost is 6 per cent. on the virtual cost	£13,400 p.a.
The Bridge has a virtual cost of £200,000 × 1·1 =	220,000
5,000 × 3 =	15,000
	£235,000
or its total annual cost is 6 per cent. on the virtual cost	£14,100 p.a.

Other considerations, of course, affect a final decision, but when it is realised that the figures given above represent roughly those for actual conditions above Victoria Bridge, and that several ferries would be needed to carry the same amount of traffic as the bridge, the economy of a bridge is apparent.

Use has been made of the curve also to compare savings; for instance, if by building a bridge in a certain position an annual saving of traffic mileage estimated at £200,000 per annum is insured, this is worth £3,340,000 as a capital sum. Consequently if the bridge to ensure such saving may be built at a virtual cost of, say, £1,700,000, that is at an annual cost of £102,000, there obtains a saving of £200,000 less £102,000, say £98,000, whereas any structure having a virtual cost greater than £3,340,000 unless other factors operate, would involve a loss.

As the figures quoted above approximate those for Brisbane, this elaboration may be thought appropriate.

The coloured wall map of Brisbane* was prepared by the Town Planning Association. One of the most pleasing features of the work of the Cross River Commission was the public-spirited action of this and other bodies in making available data and material.

The key map (Plate 1) shows the length of river in the Brisbane city area. The numbers indicate the order of time of construction of the recommendations. Tubes are shown by dotted lines.

A contour map of the city area (Plate 2) and a model,† both prepared by the Cross River Commission, show the area affected by the main proposals.

To systematize the comparison of suitable sites a table was drawn up to show a net cost or saving computed for several alternative projects. This table with the figures deduced as outlined below is shown on page 21. It will be seen that the columns of the table are headed:—

1st.—Percentage of traffic that would use the proposed bridge.

2nd.—Vehicles per day carried by new structure 15 years hence.

3rd.—Years hence Victoria Bridge will again be saturated.

4th.—Annual saving in haulage cost 15 years hence.

5th.—Other annual savings.

6th.—Annual losses due to grades, energy, and time 15 years hence.

7th.—Annual costs due to construction, maintenance, and replacements.

8th.—Other annual costs.

9th.—Net annual costs or savings.

10th.—Factors not expressed in money.

An endeavour will be made to explain the assumptions and rational deductions made for the purpose of drawing up such a table, and then show the application of these results in the form of proposed bridges, tubes, ferries, and a canal.

Taking these in order:—

1. *Percentage of Traffic Using Any One Proposed Bridge.*

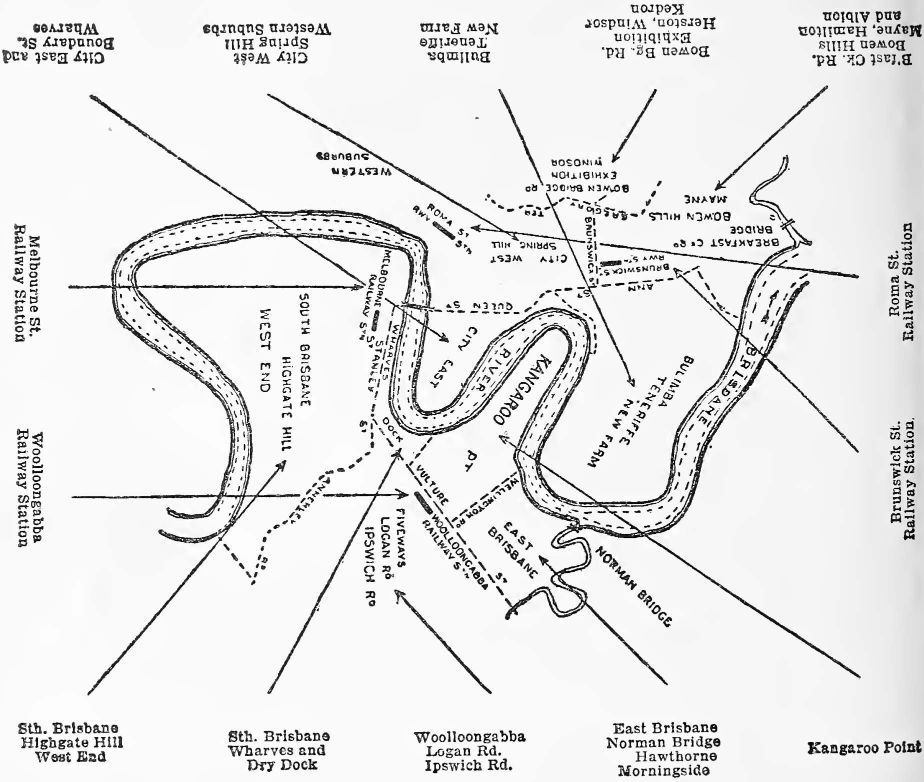
This was arrived at by an analysis of the traffic census figures; those present doubtless have some recollection of the cards (Text-figures 2 and 3) handed out at one end of the bridge and collected at the other end, each type of vehicle having a separate-coloured card. Seven areas

* The original is about 7 feet square, but is unsuitable for reproduction.

† Two models were made. The first to a scale of 200 feet to 1 inch horizontal and 20 feet to 1 inch vertical. This formed a useful table model for explanation purposes. The second was 1/200 of natural scale laid out in concrete, with which hydraulic experiments were made to determine the workability of the proposed canal.

on each side of the river were mentioned on detachable portions. Each traveller was asked to tear off the portions indicating the place or places on each side of the river between which he was journeying. From the cards collected not only the number of each kind of vehicle was found but also the places between which each vehicle was travelling.*

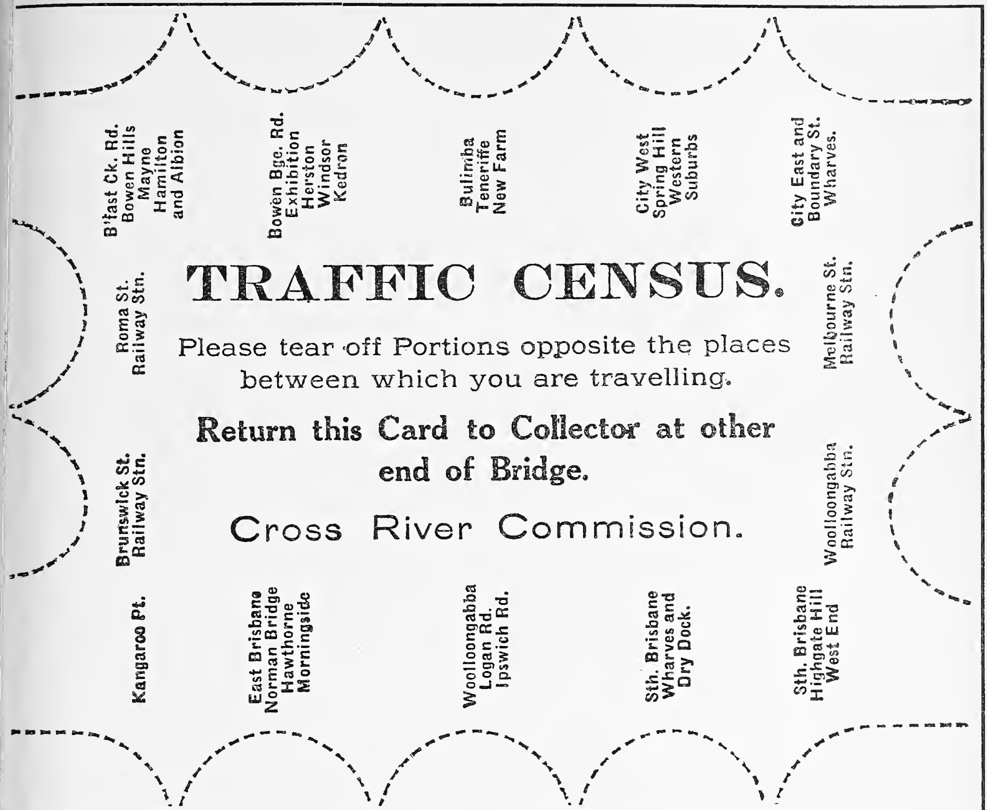
Cards were distributed and collected on the ferries and counts of foot passengers also were taken. The tram census was carried out by using special tickets, and by an analysis of the ticket collector's returns. The public in this latter case were not affected.



Text-figure 2.

Then for any assumed site, acting in conjunction with the present bridge, the route which would be followed by traffic could be discussed. For instance, assuming the Bowen Terrace site were being considered, a vehicle recorded as from Roma Street Railway Station to Melbourne Street Railway Station would certainly use the present bridge, whereas

* The small number of informal records was a tribute to the intelligence and patience of the community, and of the collecting staff. The original suggestion of such a census was made some years ago by the Institution of Engineers. The subdivisions of areas adopted was the result of much consideration and discussion among the members of the Commission. Text-figures 2 and 3 are the two faces of the one card.



Text-figure 3.

if from Brunswick Street Railway Station to East Brisbane, it would use the new bridge. Decisions as to such were simple, but for a vehicle from, say, the Exhibition to Woolloongabba, opinions might differ.

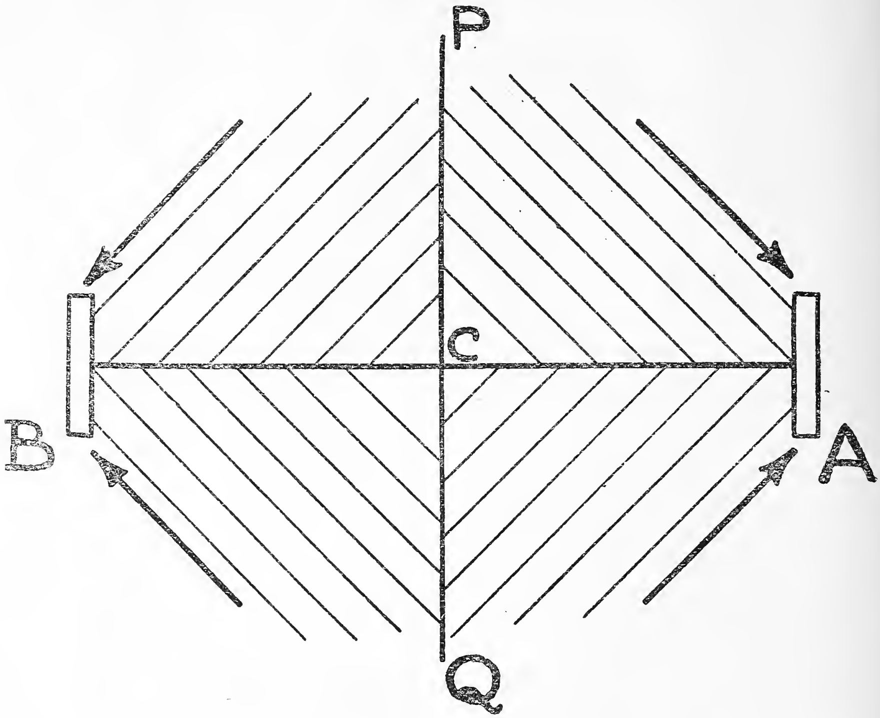
A very simple generalization assisted greatly as follows:—

Referring to Text-figure 4.—If AB is a line joining two bridge sites and PCQ bisects AB at right angles at C, it is apparent that a vehicle in the area ACP going to the area ACQ would prefer to go through A. Similarly one in BCP going to BCQ would go through B.

This is for distance only and for straight line movement, but it is reasonable to say that PQ is the dividing line of areas. The windings of the river, the presence of grades or other obstructions, cause modifications of the theoretic deductions, but the general principle was found most useful.

The numbers going between the several areas on the North side to the several areas on the South side being known from the census records, using the principle mentioned above and some judgment and knowledge of local conditions with regard to areas not otherwise determined, the number that would use a new structure was worked out for several alternatives. From this a percentage was entered as shown in Column 1. Plate 3 (left figure) represents graphically the census results.

It was considered that present relative conditions would remain for some time in the future. Computations of actual numbers were put as for 15 years hence* as shown in Column 2. The investigation for these figures and those of Column 3 will be now given jointly.



Text-figure 4.

The third column of the table, being a prediction of future events, *i.e.*, years that will elapse before traffic over Victoria Bridge again approaches 12,000 per day, has the interesting feature of prediction. The figure was necessary in order to determine the sizes of proposed new bridges or tubes. The records of previous counts of traffic were available; from these tables curves were drawn up showing the variation in numbers of each type of vehicle.

The results of the census figures for various years were condensed and rearranged, as shown in Text-figure 5.

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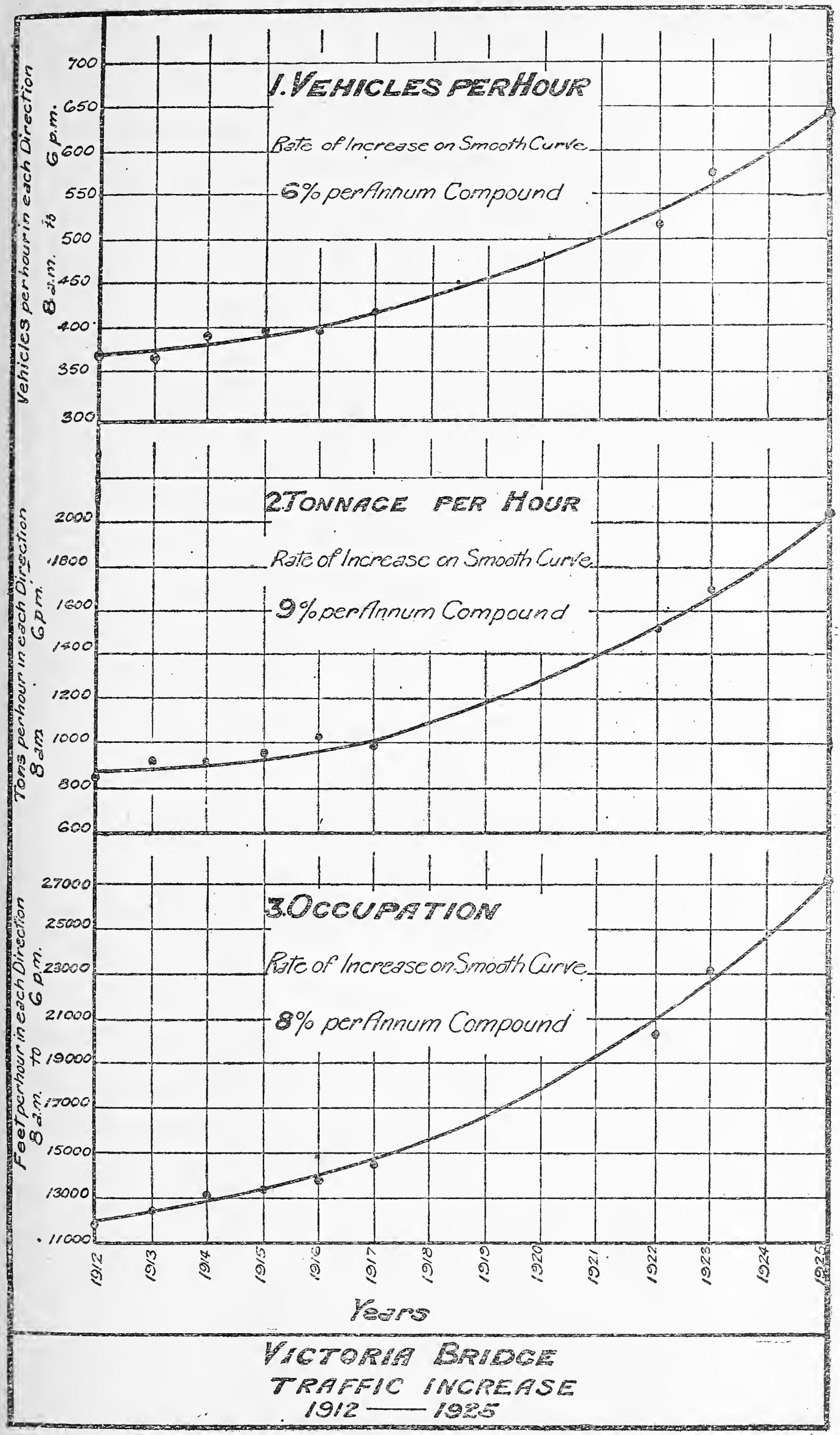
* A definite time in the future was needed, since in the computations of virtual cost there are items such as mileage and time and energy losses, which vary with the number of vehicles, whereas the construction cost of a structure is a fixed quantity. For a comparative analysis, the time 15 years ahead was chosen since conditions then can be fairly anticipated. The more rapidly developing areas are those primarily served by the new bridge, so that the error, if any, is on the right side.



Text-figure 5.

It will be realised that the number of vehicles only might not be the best measure of growth, since small vehicles have been replaced by large motor-cars, consequently Curve No. 2 was prepared on the "tonnage" basis and Curve No. 3 on the "occupation" basis; that is, allowing each vehicle a space on the bridge according to its dimensions and speed.

From the curves a rate of increase between 6 per cent. and 9 per cent. is apparent, and the figure 8 per cent. was adopted for our purpose. That is to say, if the rate of increase during the past eight years be preserved, the volume of traffic will again double itself in nine years, quadruple in eighteen years, and be eight times its present amount in twenty-seven years. Experience elsewhere has shown that traffic grows twice as fast as population, and the figures for Brisbane agree with this.*

The intensity of traffic at different portions of the day affects the carrying capacity of a bridge. For this reason the records were kept for each hour (and at busy periods, each half hour), consequently a table could be prepared showing the number of vehicles at each hour of the day, also the total number for the day. From these it was found that the maximum intensity is more than twice the mean intensity, approximately 2·2 times, and that any intensity over 500 vehicles per hour for each line of way represented congestion.

The results were applied as follows:—

> For a city bridge, 40 ft. is considered the minimum width† to allow of the passing of vehicles and general convenience. This is the effectual width of Victoria Bridge (actually it is composed of two bridges each 22 ft. 6 in. wide), and such a bridge, allowing for the double intensity during morning and evening, would have economically a capacity of 15,000‡ vehicles per day (Victoria Bridge carries 16,000 vehicles per day and the present bridge and approach streets are congested for four hours of the day). Even if a new bridge takes away 40 per cent. of the traffic, at the present growth, the traffic on Victoria Bridge will again approach 12,000 per day in three years, as shown in column 3, and provision for relief must again be sought.

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* A neat little theoretic analysis, due to Mr. G. O. Boulton, is given in Part III. of the Report of the Cross River Commission.

† The width 40 ft. was adopted by the Commission for the purpose of estimating bridge costs. Liverpool assumed 36 ft. as sufficient for four ways of traffic, but American practice, following a study of speeds (see reports of the New York Tunnel Commission) of vehicles, widths and space occupied, recommends 40 ft. as that advisable for four ways of traffic. The maximum widths of vehicles is not the only criterion for these widths, as vehicles carry loads often to a width of 7 ft. 6 in. and especially for long lengths, 15 in. clearance on each side does not seem too much for present day speeds.

‡ Of course if the traffic could be spread over say 12 hours each day, this figure would be 24,000 per day. This was the figure assumed for Liverpool; presumably there the traffic intensity is more evenly distributed than in Brisbane.

It will be clear from the figures mentioned that in fifteen years hence 52,000 vehicles will be crossing per day, the increase being at 8 per cent. compound interest on present traffic, and that bridges of say three times the capacity of Victoria Bridge will be required within the next eighteen years, and as it takes five years to build one of these structures, an early start is necessary.

The inconvenience and risk caused by congestion are undoubtedly great; yet these effects only apply for portion of the day and to a portion of the vehicles, whereas the losses due to detours and grades apply to every vehicle. Grades in themselves also tend to cause congestion through the difficulties of starting and stopping and to the loss of speed.

The effects of detours will be discussed now and those of grades will be discussed in detail later.

In order to make comparisons in terms of money it was necessary to work out a value of each vehicle-mile. That is to say, the cost of running each vehicle one mile, such cost to include the value of the occupant's time and the cost of replacements and overhead charges. Such a calculation was of the kind familiar to engineers, a compound of scientific analysis, assumption and compromise, always new, rarely precise, but necessarily decisive.

A separate-coloured card was used for each type of vehicle. From the census record was obtained the proportional number of each kind of vehicle.

It was thus possible to compute the cost of running an imaginary average vehicle. The analysis for vehicles was shown separately from that for trams, since their properties are so different.

The average distance saved by a vehicle travelling between each two areas was deduced by examining the route expected to be followed and knowing the number travelling on each route, an average mileage saved by the new project was computed; then

$$\textit{Number of vehicles} \times \textit{mileage saved} \times \textit{value per mile}$$

gave the saving to be expected.

Table I. shows the results for the major recommendation of the Commission.

The fourth column of Table II. given on page 21, and the census deductions expressed by diagrams similar to Plate 3, show the relative merits of various sites from the point of view of the amount of traffic that would use it and the mileage saved, as compared with the present site, provided other conditions are equal.

Column 5, "other savings," tabulated such things as elimination of existing ferries, &c.

TABLE I.

Annual Saving in Haulage Cost (Distance only, Grade effects zero), for the Commission's Major Recommendations I. to IV., considered as a whole.

The Commission's Major Recommendations Comprising		Percentage of cross-river traffic carried	Miles saved per vehicle for given percentage	Cost per vehicle mile (pence)	Six Years Hence: Vehicles per day =1.6 times present value *	Six Years Hence: Daily Saving	Six Years Hence: Annual Saving per year of 340 days	Fifteen Years Hence: Vehicles per day =3.2 times present value *	Fifteen Years Hence: Daily Saving	Fifteen Years Hence: Annual Saving per year of 340 days
I. Petrie's Bight	Vehicular Traffic	41	.85	13.6	9,400	£450	£194,000	† 16,140	£900	£388,000
	Tramcars	32	.32	98.3	910	£120		1,820	£240	
II. Grey Street	Vehicular Traffic	21	.31	13.6	4,750	£82	£28,000	9,500	£164	£56,000
	Tramcars	—	—	—	—	—		—	—	
III. Victoria Bridge	Vehicular Traffic	38	—	—	8,850	—	—	† 16,820	—	—
	Tramcars	68	—	—	1,930	—		3,860	—	
Total					25,840	£652	£222,000	48,140	£1,304	£444,000
IV. Sydney Street Transporter	Vehicular Traffic	** 8	.57	13.6	Not yet constructed			** 3,540	£114	£39,000
	Tramcars	—	—	—				—	—	
Total								51,680	£1,418	£483,000

* Assuming annual rate of traffic increase, 8% compound.

** Comprising 6% from Petrie's Bight bridge—*i.e.*, 2,660 vehicles. 2% from Victoria Bridge—*i.e.*, 880 vehicles.

† Exclusive of vehicles using Sydney Street transporter.

It remains to investigate the cost of the kind of structure suitable to any one site in order that the net relative costs or savings for all sites may be determined.

If there were no shipping to consider the choice of sites would be simple, but having obtained estimates of the cost of building new wharves down stream and of the losses entailed to the city as a whole by the closing of the river to seagoing vessels, say from Wellington road upstream, the figures supplied us were so large that any economy of bridge construction or traffic convenience obtained by low-level bridges closing the river would be negatived. On the contrary the aim was, if possible, to increase facilities for large shipping.

To provide facilities for shipping, four methods are available:—

(*a*) A tube under the river,

(*b*) A high-level bridge in one clear span over the river,

(*c*) An opening bridge that will allow ships to go through, involving a stoppage of road traffic for a certain time,

(*d*) A diversion of portion of the river along which shipping would go and over which a high-level bridge could be built at perhaps less cost than is involved in (*a*) or (*b*).

In connection with (*a*) and (*b*), that is, a tube and a high-level bridge, two intensely important factors affect location. These are:— First, the necessary grades, and second, the rise and fall. The two are interconnected but allow of separate methods of treatment. An attempt at expressing the effects of these in terms of money has been made. Previously in an investigation of this kind, a ruling grade having been adopted, the height of the bridge was kept as low as possible, but no quantitative analysis was made that would ensure that relative effects could be determined.

The main features of this investigation will now be outlined.

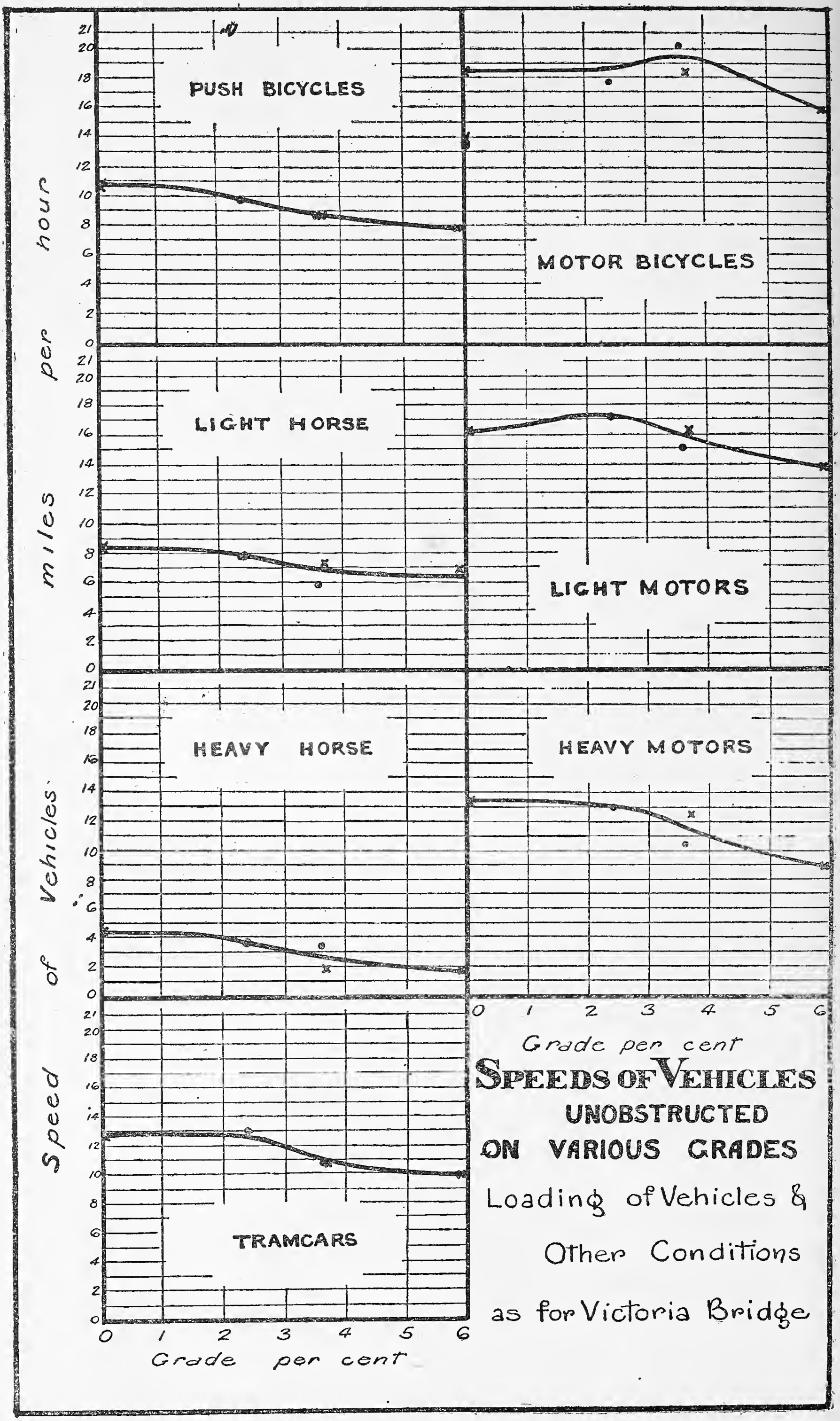
The effect of grades is reflected in two ways, classified here as "time losses" and "energy losses" respectively, though as mentioned the two are interconnected. The value of time varies with each person and vehicle, and with the hour of the day.

As a conservative figure the basic wage 2s. an hour was adopted for each person, with a few exceptions, such as tram drivers.

The loss of time caused by grades is readily deduced if the assumed data is constant, since power × speed is equal to "work" done or energy used and/or stored up, so that if a grade* multiplies the

---

* When it is known that the resistance on a flat grade for a modern city road is say 25 lb. per ton weight, whereas on a 1 in 20 grade the resistance is 137 lb., that is, over five times as much as on a flat, it will be realised how essential it is to preserve easy grades. The apparent paradox arises that the better the road surface the easier grades ought to be to get the best economy. For rough roads the resistance on a flat was say 80 lb. and on a grade of 1 in 20 it would be say 192, *i.e.*, only 2½ times as much as on the flat, and it did not pay to expend large sums on getting easy grades, but with modern city smooth pavement the case takes a new aspect.



Text-figure 6.

resistance, the speed drops accordingly, providing the power is kept constant. Or alternatively, if the same speed is to be preserved the horse-power must be multiplied in proportion to the resistance. Men and horses have a margin of power; for instance, some people run between wickets and others to catch a train, but this can be kept up only for a limited period. Motor-cars and trams have reserves of power for quick starting, for emergencies and to preserve their speed, so that for vehicles having a range of power any theoretic estimation of average actual losses caused by grades becomes very complicated.

Many computations were made during the investigations of the Commission and strenuous discussions entered into as to the actual figures appropriate to each case. Finally experiment was decided on. Men stationed with field glasses and stop watches at convenient points observed the passage of vehicles over two separate stretches of road for some days, and also over Victoria Bridge. The plotted results are shown in Text-figure 6. The drop in speed on grades is definite. The minimum grade recommended for bridge approaches in England and America is 1 in 30. In our observations even on this grade nearly all the vehicles showed a decided loss of speed. These experimental results confirmed the Commission in their recommendation that the limiting approach grades should be 1 in 30.

Because this result has such an important bearing I have gone into some detail. It is a main cause of the great expense of tubes and high-level bridges, since it causes extra length*; again, steep grades cause waste of time and energy. In smaller country bridges and in some city bridges the effect of grades has been neglected; in the latter case with serious results on the efficiency of the structure.

The energy losses or effect of rise and fall had not, so far as we know, been done previously in a form suitable for our purpose. It is obvious that, in going up a grade, power is used to overcome resistance and to store up energy, and that, in going down, part of such energy is wasted in heat with the consequent wear. It is presumed here that the momentum acquired running down-hill cannot be used to climb the next hill; such is only possible on an open road, and then only to a limited extent. No previous estimate was available, though it is mentioned somewhere that—

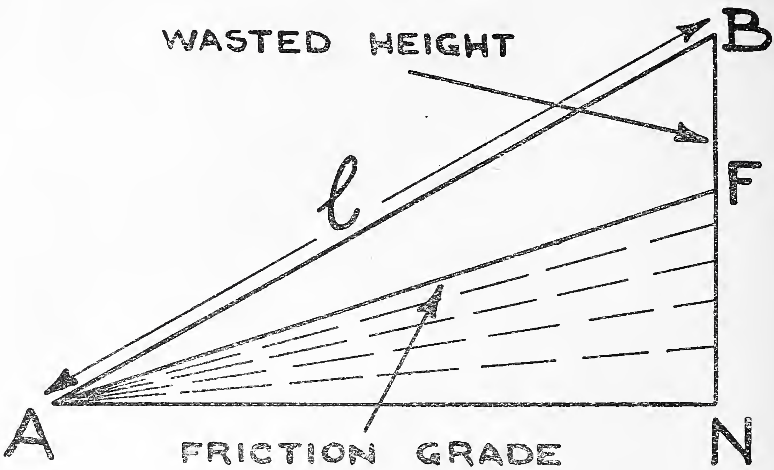
> "The famous Duke of York
> He had ten thousand men,
> He marched them up a hill
> And marched them down again."

The recorded results of this experiment were useless for the present purpose.

If one is locating an approach road specifically to one point on the top of a hill, the steepness desirable is limited by the power of

* For instance, to rise 100 ft. on 1 in 30 requires a length of 3,000 ft.; this on each side of the river and 1,000 ft. width of river makes 7,000 ft. the approximate length of a tube if built or of a high-level bridge, including approaches.

vehicles, convenience of drainage and the other factors affecting road construction. If, however, as in the present case, two points at about the same level and on different sides of a river are to be connected, then the only grade that involves no loss of energy is that on which brakes are not required, what we have called the "Friction Grade."* That is to say, one can go up and down on such a grade by using the same amount of energy as would be used in going the same distance on a flat. On any steeper grades, up and down, there is a loss of energy measured by the weight lifted multiplied by the "wasted height" (see Text-figure 7); that is, the total rise less the height that would be



Text-figure 7.

reached on the friction grade on the same length. The effect of this is the use of extra power going up (in a motor-car measured by petrol and wear and tear) and going down the energy of position or "potential energy" thus gained is lost in heat caused by the brakes. Each vehicle is presumed to return so that only the tonnage one way is to be taken for total loss.

For a long length of various grades the computation has been generalised, with the result as follows. If the "average grade" be computed over the length, always assuming that a grade less than the friction grade, including a flat, is considered as the friction grade—

If $f =$ friction resistance per ton, say about 28 lb.

$g_a =$ average grade.

Then the mean tractive effort is $\frac{f + g_a}{2}$

and the extra tractive effort over that for a flat or friction grade is

$$\frac{f + g_a}{2} - f = \frac{g_a - f}{2}.$$

* The "friction grade" varies with the vehicle; for trams it is about 1 in 100. For other vehicles 1 in 80 was assumed for modern smooth city streets. The apparent paradox appears that the better the road surface the easier the grade should be to get the best economic advantage.

I might state that this simple formula was the result of many weeks of joint work and thought. The Technical Assistant to the Commission, Mr. G. O. Boulton, B.E., in this, and throughout the detailed computations, did excellent work.

For example, for a one-span bridge to Bowen Terrace rising to a deck level of about 110 feet above high water, it was found $g_a = 63$ lb. per ton. That is to say, the conditions are equal in effect to going over a rough road.

Since $f = 28 \therefore \frac{g_a - f}{2} = 17{\cdot}5$ lb. per ton weight.

The length over which this applies in this case was 3,570 feet.

Dividing by 2,240 to bring the result to tons we get

$$\frac{17{\cdot}5 \text{ lb.} \times 3{,}570 \text{ ft.}}{2{,}240} = 28 \text{ ft. tons of excess of energy used per ton.}$$

and for this bridge, taking 33,000 tons per day as the weight of vehicles we get—

33,000 tons lifted per day $\times$ 28 ft. tons = 925,000 foot tons per day.

By such methods for each respective length of bridge and approaches, the foot tons of energy lost were computed.

Turning now to the cost in money of losses of time. The value of each minute for each type of vehicle and thus for the average vehicle was computed by a detailed analysis for each vehicle, and knowing the proportion of each, for an average vehicle. Then multiplying the number of vehicles by the loss of time by the value of one minute to each respective vehicle, the daily money losses due to loss of time were obtained.*

As regards energy losses. The cost per foot ton was deduced from that per vehicle mile by computing the number of foot tons per mile for the average grade of Brisbane. Then multiplying the foot tonnage lost by the cost per foot ton, the money losses due to energy used were obtained.

The total time and energy losses due to grades for various alternative proposals are shown in separate colums of Text-figure 8.

So far as we know, this method of stating savings and losses in money values is new, and to that extent doubtful. We are aware that many assumptions have had to be made, but the fundamental reasoning is that of scientific engineering practice and the figures may be considered as reasonably accurate for the purpose of relative comparison. The accuracy is comparable with that of figures for construction cost, &c.

* The money effect of loss of time due to vehicles having to pass through congested areas, over crossings, &c., could be similarly computed, but up to the present has not been done. A series of observations of the time lost by typical vehicles in passing over a certain number of crossings would be needed so that the figures of cost mentioned in the text could be applied.

MONEY VALUE OF ENERGY LOSSES AND TIME LOSSES.

On Various Bridges due to Grades, as Compared with Level Routes.

Traffic as for 15 Years hence.

Mileage from River Mouth	Location		Vehicles per day carried fifteen years hence	Tons per day carried fifteen years hence	Energy Losses 15 Years Hence: Daily Energy Losses Ft. Tons	Energy Losses 15 Years Hence: Power Cost per Ft. Ton Pence	Energy Losses 15 Years Hence: Daily Loss	Energy Losses 15 Years Hence: Annual Loss @ 340 Days per Annum	Time Losses 15 Years Hence: Daily Time Losses Vehicle Minutes	Time Losses 15 Years Hence: Time Cost per Vehicle Minute Pence	Time Losses 15 Years Hence: Daily Loss	Time Losses 15 Years Hence: Annual Loss @ 340 Days per Annum	Total Losses 15 Years Hence
12.7 M	George Street Deck Level 192	Vehicular Traffic	16,100	32,800	656,000	.019	£ 52	£23800	3750	1.11	£ 17	£9,200	£33,000
		Tramcars	2,040	27,500	620,000	.007	£ 18		185	12.9	£ 10		
12.1 M	Petrie Place Deck Level 192	Vehicular Traffic	18,800	38,300	820,000	.019	£ 65	£28,000	4650	1.11	£ 21·5	£10,500	£38,500
		Tramcars	1,820	24,500	590,000	.007	£ 17		175	12.9	£ 9.5		
12.1 L	Petrie Place Two Deck { 168 / 148	Vehicular Traffic	18,800	38,300	0	.019	£ 0	£ 0	0	1.11	£ 0	£ 0	£ 0
		Tramcars	1,820	24,500	0	.007	£ 0		0	12.9	£ 0		
12.0 M	Bowen Terrace Deck Level 203	Vehicular Traffic	16,200	33,000	925,000	.019	£ 73	£28,800	5250	1.11	£ 24	£10,200	£39,000
		Tramcars	910	12,300	390,000	.007	£ 11.5		115	12.9	£ 6		
12.0 H	Bowen Terrace Deck Level 224	Vehicular Traffic	16,200	33,000	1680000	.019	£ 133	£52,000	13500	1.11	£62·5	£27,000	£79,000
		Tramcars	910	12,300	680000	.007	£ 20		305	12.9	£16.5		
11.3 L	Merthyr Road Opening Span	Vehicular Traffic	11,200	22,800	0	.019	£ 0	£ 0	0	1.11	£ 0	£ 0	£ 0
		Tramcars	510	6,900	0	.007	£ 0		0	12.9	£ 0		
	Tube	Vehicular Traffic	Say 16,100	32,800	2070000	.019	£ 164	£75,000	11900	1.11	£ 55	£29,000	£104000
		Tramcars	Say 2,040	27,500	1970000	.007	£ 57·5		580	12.9	£ 31		

Text-figure 8.

The calculations mentioned apply to tubes with equal force, and so far as energy is concerned the waste in going down and then going up is the same as going up and then going down; the figure for a tube is shown at the foot of the table in Text-figure 8.

The "waste" mentioned means, of course, to the community as a whole; no doubt if steep grades were used less loads would be carried per vehicle, and consequently more vehicles employed, so that some portions of the community might even gain. Similarly a more expensive structure provides money for some, but it seemed to us a sound economical principle to eliminate unnecessary expenditure wherever possible.

The figures for these time and energy effects should be added to any estimate of cost. When a high bridge or tube is being fully occupied the cost to the community due to the operation of the factors mentioned is comparable to and may even exceed that due to construction and maintenance.

It is quite possible that in some cases circumstances demand the construction of a tube or high-level bridge, but this would be after a close examination of alternatives. For instance, in Liverpool, England, a tube 11,000 feet long is now being built. This is to cost five and a-half millions, and has a 36-ft. road and two lines of trams. A low bridge in such a port, carrying many of the largest ships of the world, was not considered so far as the report of the investigators shows, but the alternative high-level bridge was to cost eleven millions. It is worthy of note that the rise and fall effects for the tube were less than those for the bridge, since the latter was to be 180 feet high, but no quantitative calculations have been published.

In Brisbane a low-level bridge 10 feet above highest flood level, on piers, together with a canal, giving a passage for ships practically equal to that of a single-span bridge, would virtually cost one and three-quarter millions, whilst the tube or high-level bridge would cost five millions; consequently our recommendations were in the former direction.

The constructional costs have next to be considered as shown in Column 7. To obtain these, estimates were prepared of the costs of—

(A) A bridge 40 feet wide as—
- (*a*) One span.
- (*b*) Several spans on piers with approaches above flood level.
- (*c*) A bascule bridge.

(B) A transporter bridge.

(C) Ferries—
- (*a*) To carry a tram.
- (*b*) To carry a motor-bus and vehicles.

(D) Tubes for—
- (*a*) Two ways of traffic (20 feet).
- (*b*) Four ways of traffic and two tramways, equivalent to a roadway of 60 feet.

These estimates were prepared by specialists for the general conditions of location, capacity, &c., laid down by the Commission.

In the case of the tubes the figures for the latest constructions in England and America were available and served as a basis.

A careful study of these estimates was made and the essentials for the present purpose entered in Column 7.

Other losses in Column 8 were entered as shown after a careful review of possibilities.

The detailed comparison was required mainly for the determination of the site and type of structure for the first bridge. The results of the comparison are finally summarised in Table 2, which shows the figures deduced during the investigations for the main projects in Brisbane.

This table was the main deciding factor in the recommendations made as to the first four projects to be constructed.

The results of expected traffic distribution were expressed graphically and to scale as shown in Plate No. 3.

The fact that the proposed bridgehead for the economic traffic distribution and economy of construction came to an intersection of several streets led the Commission to suggest a traffic circle, as shown in Plates 4 and 5. This is of special interest, as since January 1st, 1926, London has adopted gyratory control of traffic at Parliament Place, apparently with great success.

From the newspaper correspondence and from conversations with friends it would seem necessary to enlarge on the reasons for, firstly, building a canal, and secondly, the location chosen.

A low-level bridge could be built with an opening span in it, but for navigation purposes it would need to be placed where at least ½ mile of straight run would be allowed for ships approaching the opening. Such a site in Brisbane would not be convenient for road traffic.

Again, the Commission is of the opinion, and I think it will be generally admitted, that a main bridge opening for all shipping and blocking the traffic for at least 15 minutes on each occasion would be hopelessly inconvenient and wasteful. Consequently sufficient height for a ship to pass under must be given. For Brisbane conditions 75 feet is that economically practicable wherever a bridge be built. By cutting the canal as shown where the ground level is 90 feet above low water and putting an ordinary truss bridge over it, the necessary height is given. The bascule lift span of the Recommendations is an emergency provision so that the largest of ships may pass if required. It is not necessary to the project if such is to be compared with a one-span bridge.

The site chosen gives a shorter passage for most of the shipping and being in rock will be easy of upkeep. Again, the excavated rock we were assured by a competent authority would be of sufficient value for road metal and other purposes to pay for the excavation of the canal. In

TABLE II.

An Economic Comparison of Certain Schemes, each considered as a separate alternative, acting in conjunction with Victoria Bridge.

Traffic as for 15 years hence, assuming annual increase at 8 per cent. compound.

Mileage from River Mouth.	Location.	Percentage of cross-river traffic using proposed scheme.	Vehicles per day carried by proposed scheme 15 years hence.	Years hence that traffic on Victoria Bridge would again reach 12,000 vehicles per day.	Annual saving in haulage cost 15 years hence.	Other savings (annual).	Annual losses due to grade (energy and time) 15 years hence.	Annual cost, including first cost, maintenance, operation, &c., for 60 ft. carriage-way.	Other costs (annual).	Nett annual effect 15 years hence.	Factors not expressed in money.
14·0 L	Victoria Bridge (widened), or Bridge in immediate vicinity	100	51,700	Already in excess	..	..	..	£20,000	..	Loss £20,000	Capacity of approach streets insufficient to feed bridge
12·7 M	George Street to River Terrace. Deck level 192	35	18,100	2	£380,000	..	£33,000	£90,000	Cutting masts and funnels, £2,000	Saving £255,000	Through traffic traverses City area
12·1 M	Petrie Place to Kangaroo Point. Deck level 192	40	20,600	3	£388,000	Ferry eliminated £7,000	£38,500	£90,000	Cutting masts and funnels, £2,000	Saving £264,500	Possibility of cutting down "hump" in Main Street
12·1 L	Petrie Place to Kangaroo Point. Two deck, 168-148	40	20,600	3	£388,000	Ferry eliminated £7,000. Porphyry £12,000	..	£103,000 (80-ft. carriage-way)	Delay due to ships entering canal, £10,000	Saving £294,000	80 ft. width for traffic possible. Traffic crosses at different levels
12·0 M	Bowen Terrace to Kangaroo Point. Deck level 203	33	17,100	1·5	£332,000	..	£39,000	£91,000	Cutting masts, £1,000	Saving £201,000	Possibility of cutting down "hump" in Main Street
12·0 H	Bowen Terrace to Kangaroo Point. Deck level 224	33	17,100	1·5	£332,000	..	£79,000	£92,000	..	Saving £161,000	Possibility of cutting down "hump" in Main Street. Expenses of cutting Ivory Street precincts
11·3 L	Merthyr Road to Cairns Street. Opening span	23	11,700	Already in excess	£248,000	..	..	£42,000	..	Saving £206,000	Interruption to traffic by shipping
—	Tube	35	18,100	2	£380,000	..	£104,000	£250,000	..	Saving £26,000	Dependence on continuity of lighting and ventilation

our estimates, however, we put the cost of cutting the canal at £400,000. Even with this figure added the project has a virtual cost of about one million less than alternatives. Full provision has been made in the estimates for tractors to draw ships through the canal without delay if such desire it. Many boats will probably steam through unassisted.

Looked at from a general way a bridge a mile long and 75 feet clearance is to exist, of which nature has provided two-thirds of a mile in the form of Kangaroo Point. The subsidiary utilities of the canal for ferries, &c., are many. The hydraulic properties are now being examined experimentally, but sufficient has been done in this to show that no eddies or dangerous currents are formed; in fact it will tend to improve the river channel.

As the city grows traffic in the streets has to be regulated and it seems reasonable to expect that the same will apply to river traffic.

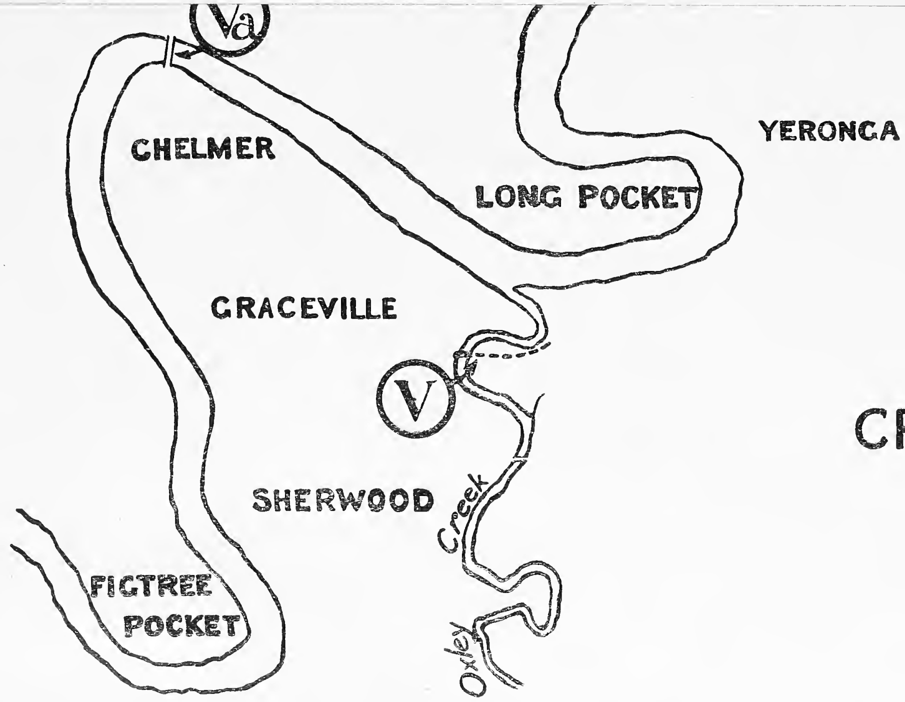
For this project the economy shown is additional to its capacity of carrying the largest percentage of traffic; of relieving city streets and saving long detours; of picking up traffic with a minimum of interference; of having a very stiff bridge of the most modern design and of ample yet not wasteful dimensions; of a certain picturesqueness; of quickest and easiest route; and of allowing facilities for shipping at least equal to that given by any economical alternative. It will fit in with the growth of the city for the next generation and can be built with Australian material and labour.

It will be remembered that the Commission was asked to recommend sites for the future and for the whole Greater Brisbane area.

The location of the other sites was gone into on the same general principles. Plate 1 shows the recommendations made.

The full details will be found in the Report of the Cross-River Commission appointed by the Brisbane City Council. The author was Chairman of the Commission and was responsible for the general procedure of the investigation. My thanks are due to the Mayor of Brisbane for the use of the model and figures from the report.

[The address was illustrated by 40 slides of which a few typical ones have been reproduced. A demonstration of river flow in the large model followed the address.]



KEY MAP

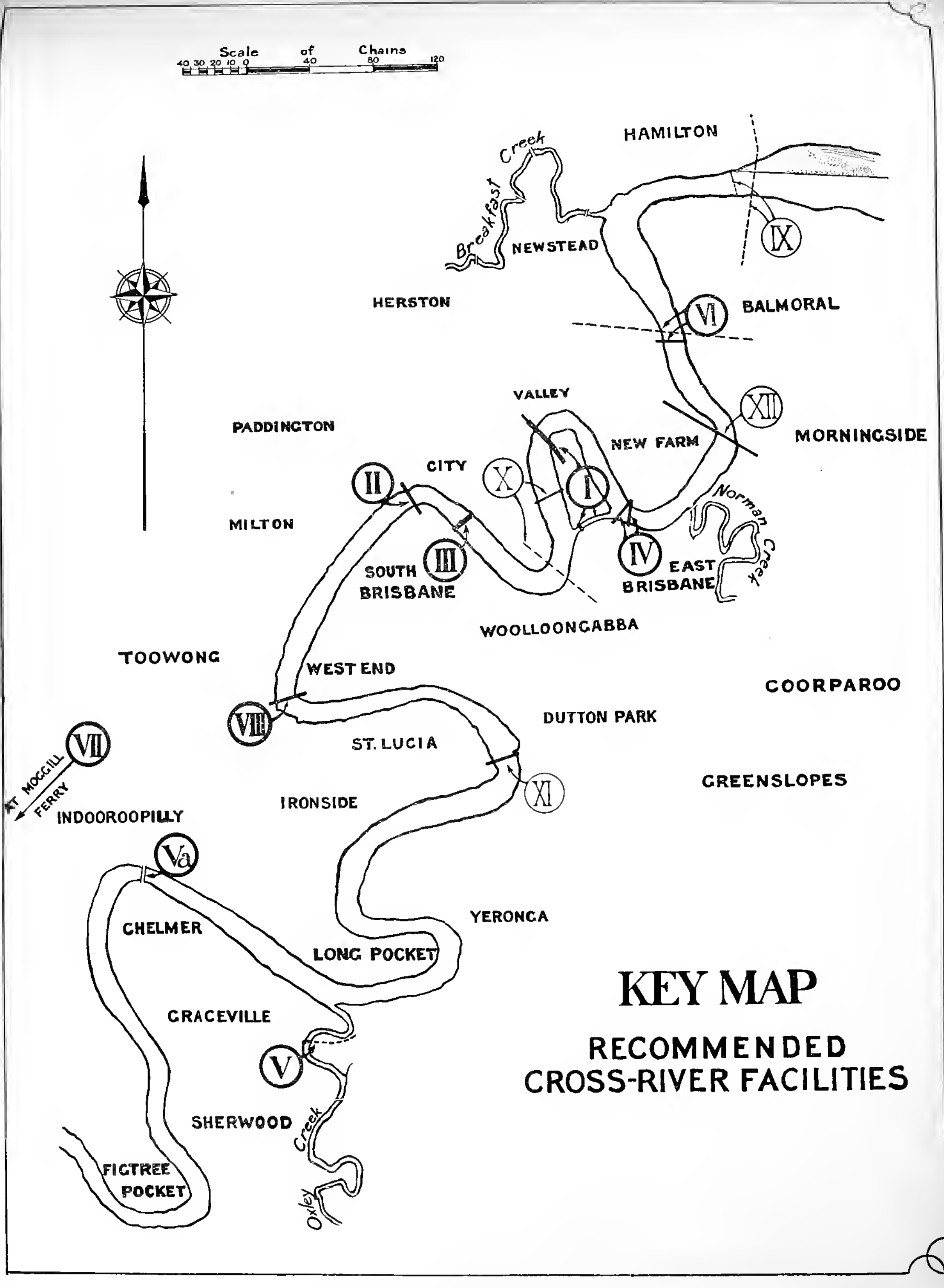
RECOMMENDED CROSS-RIVER FACILITIES

[Fo

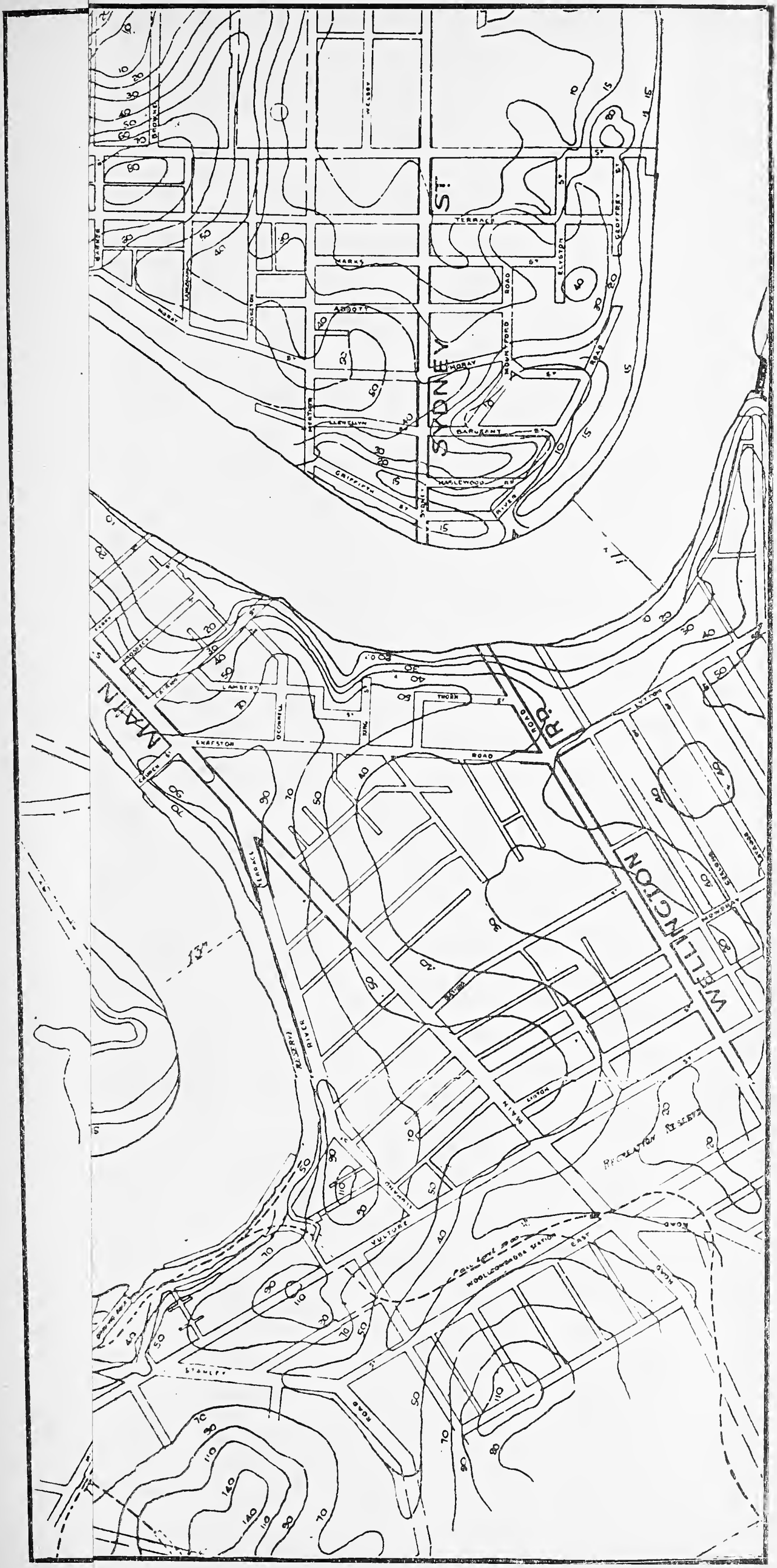
Proc. Roy. Soc. Q'land, Vol. XXXVIII.

Plate I.

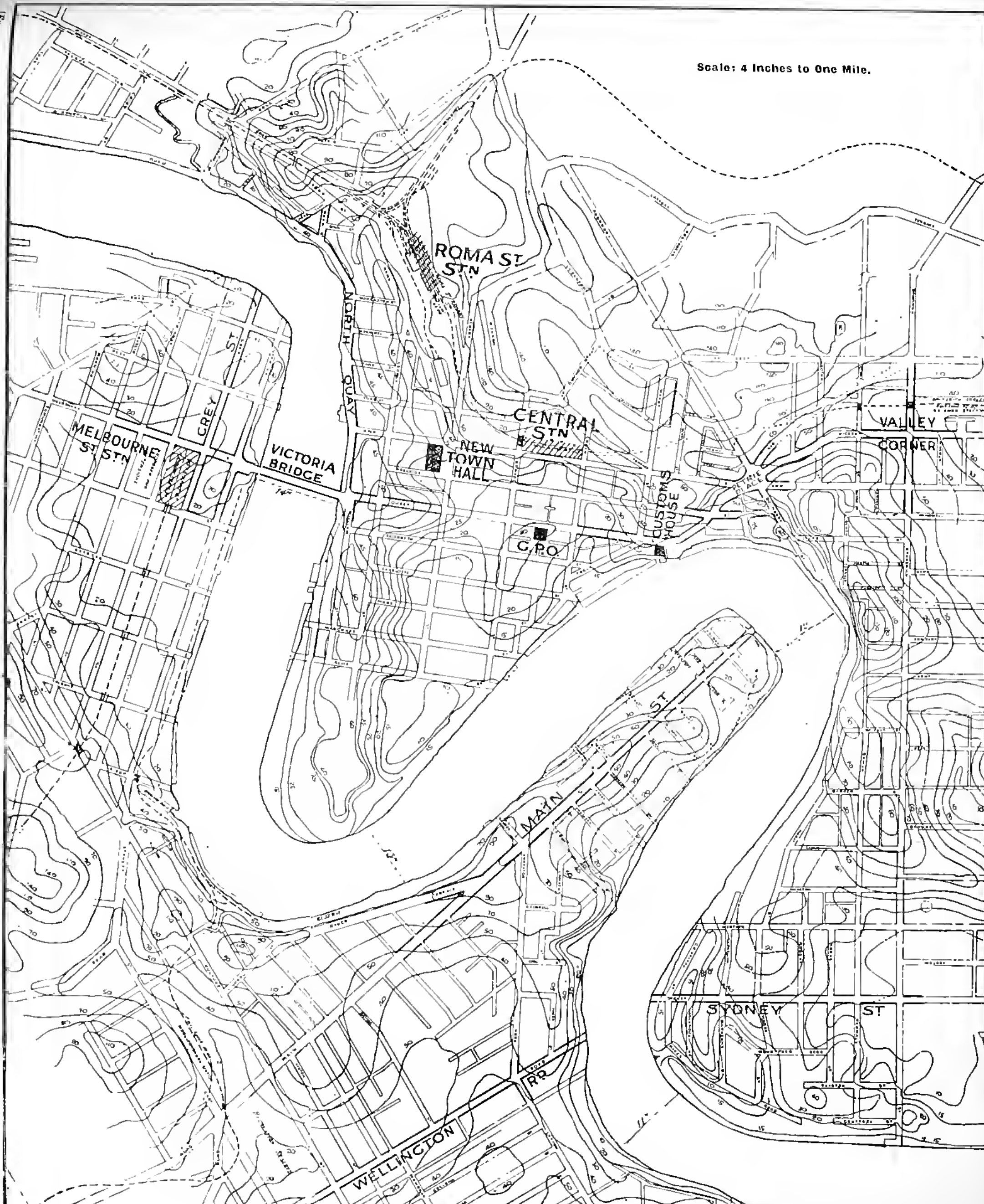
[Face page 22.]



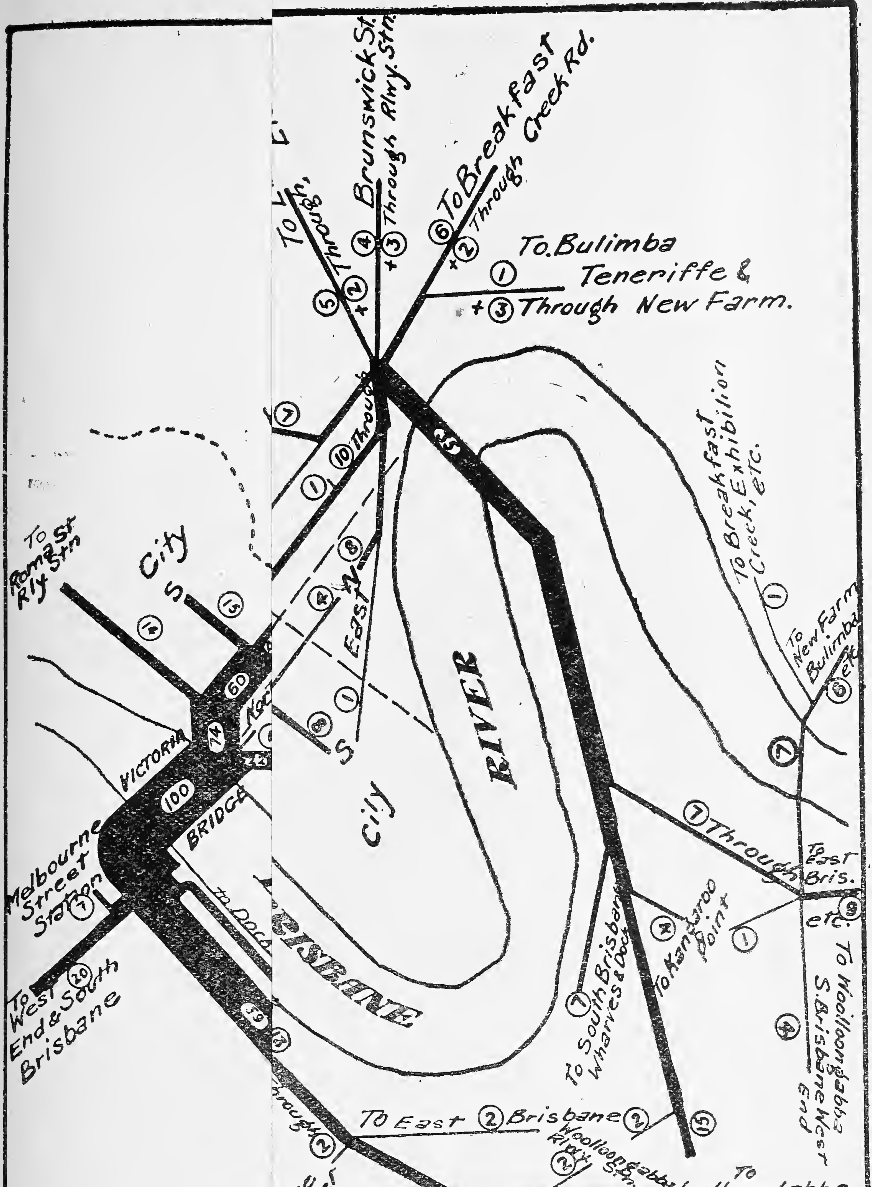
LAN, BRISBANE RIVER AND ENVIRONS.



[Face page 22.]



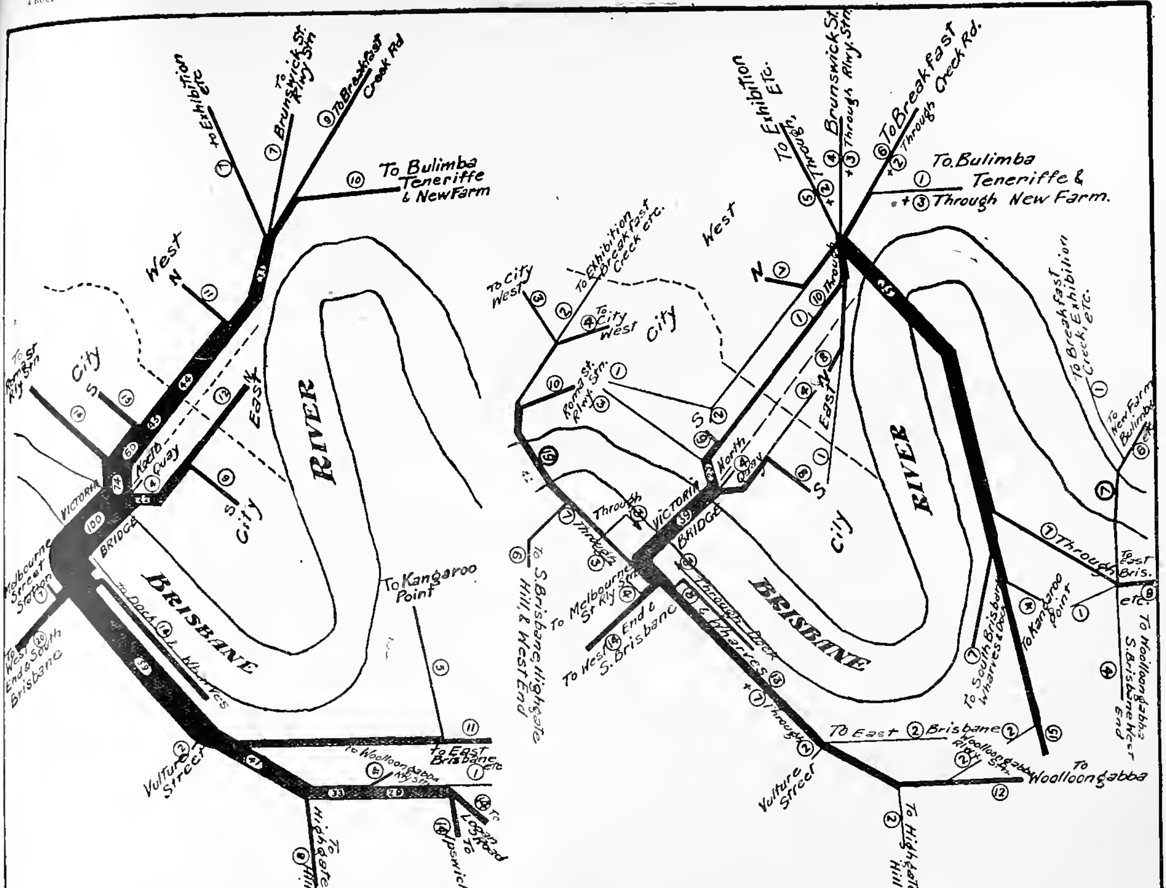
CONTOUR PLAN, BRISBANE RIVER AND ENVIRONS.



Pr Recommendations

Commission

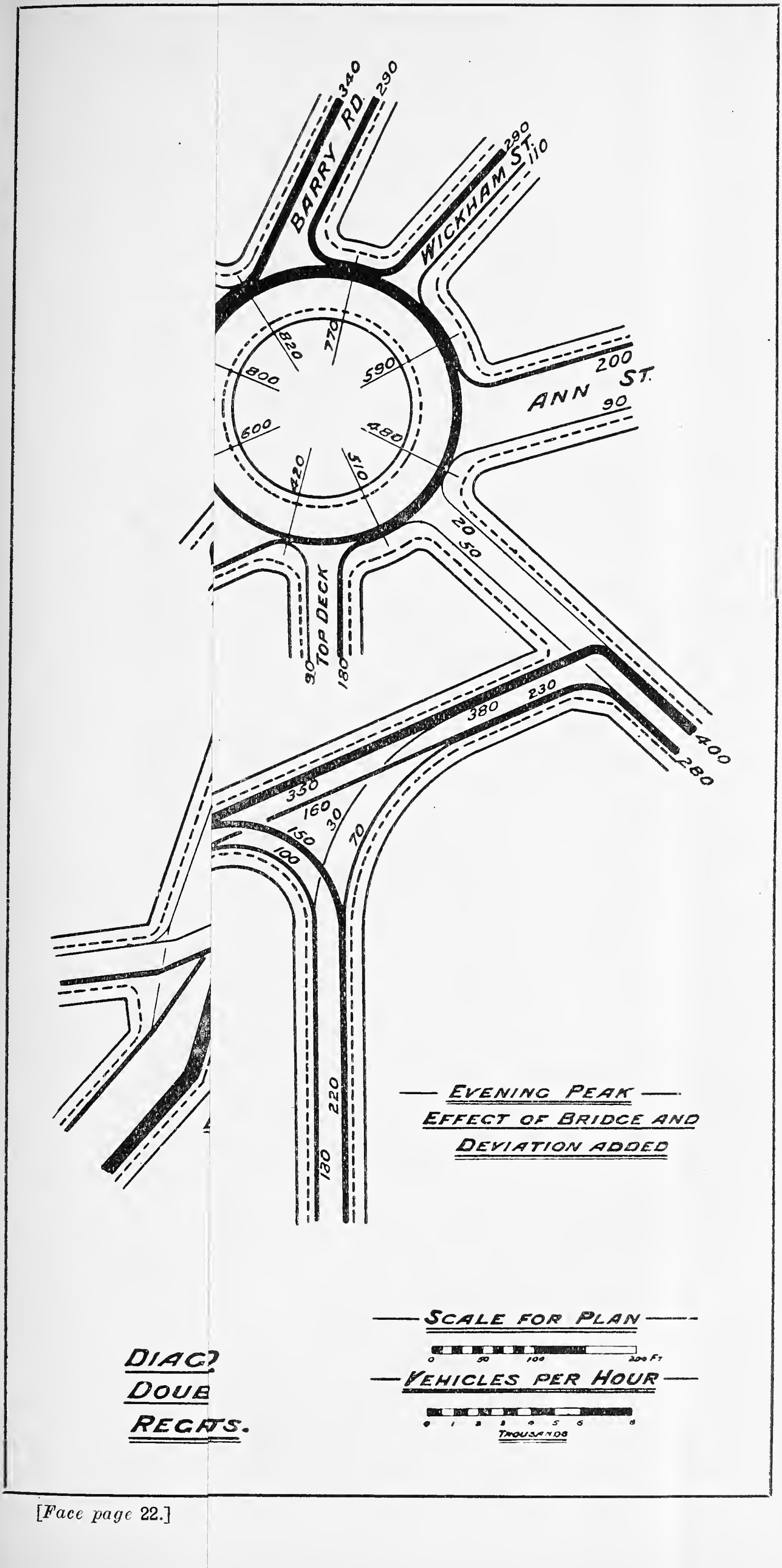
ER TRAFFIC



Present Condition Victoria Bridge

The Major Recommendations of the Commission

DISTRIBUTION OF CROSS RIVER TRAFFIC



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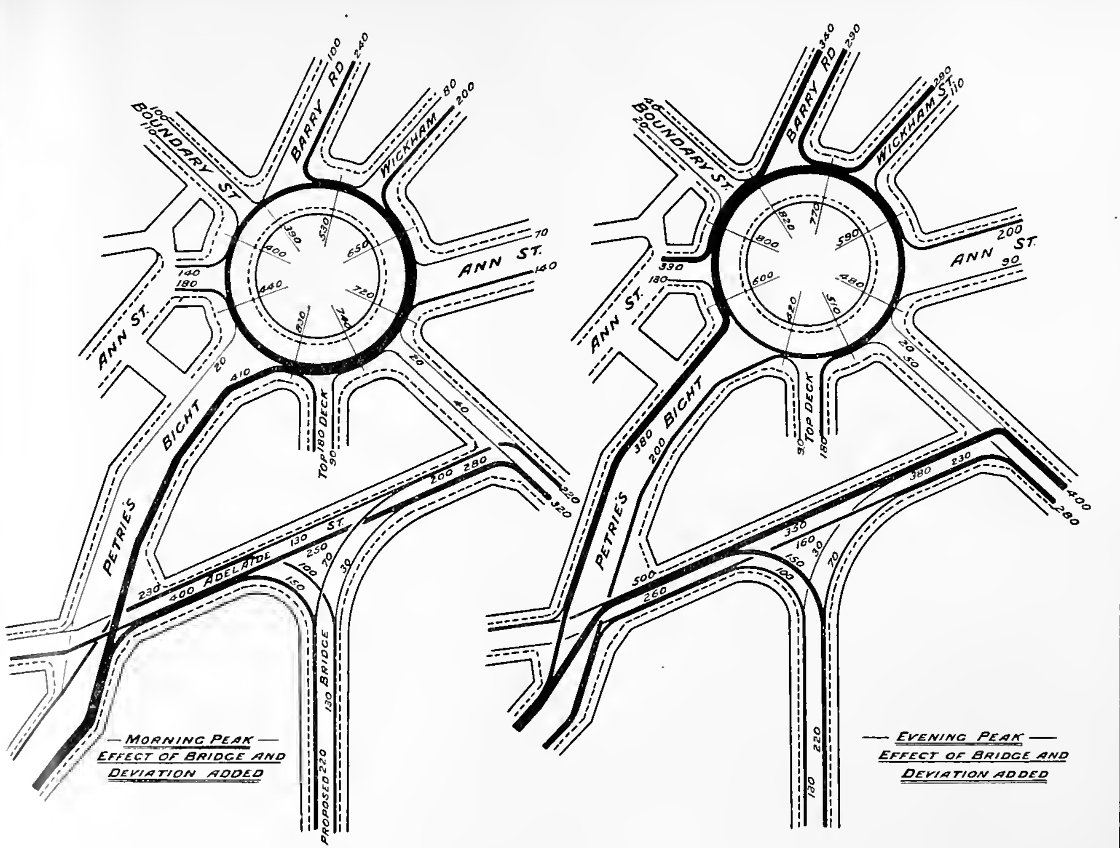


Proposed Traffic Circle

Diagram of Hourly Traffic Intensities with proposed Double Deck Bridge — Recommendation I — added and Regrading parts of Ivory, Boundary, and Adelaide Sts.

Scale for Plan

Vehicles per Hour

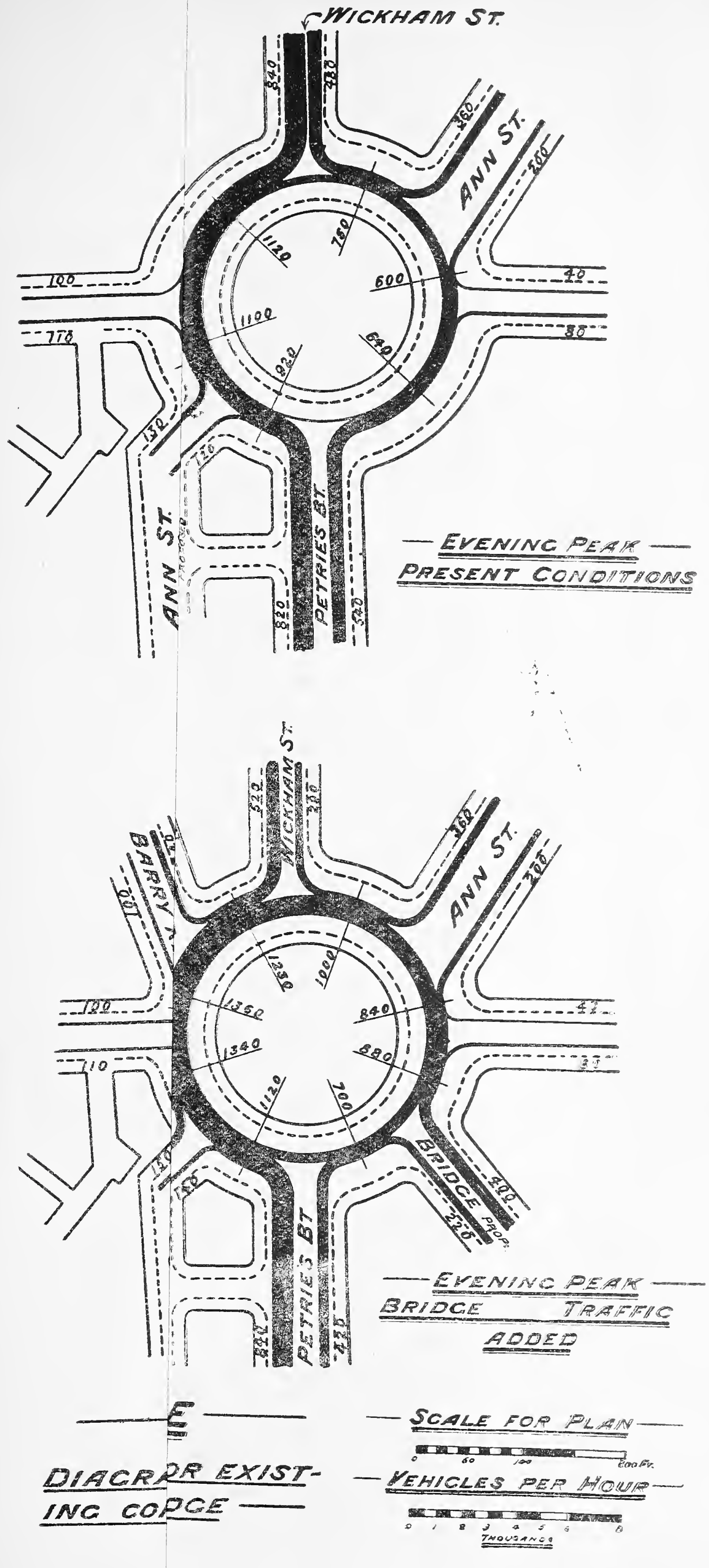
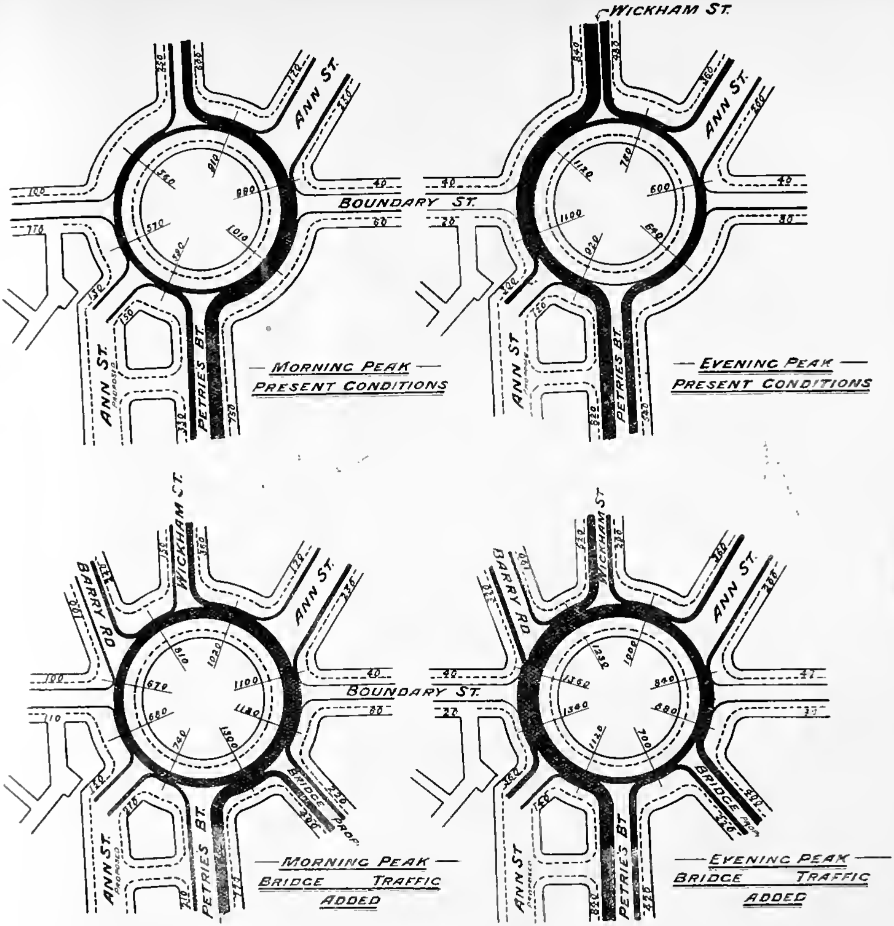


DIAGRAM FOR EXISTING CO…GE



PROPOSED TRAFFIC CIRCLE

DIAGRAM OF HOURLY TRAFFIC INTENSITIES FOR EXISTING CONDITIONS AND WITH SINGLE DECK BRIDGE (ALTERNATIVE B2) ADDED

SCALE FOR PLAN

VEHICLES PER HOUR

THOUSANDS

The Tertiary Deposits of the Moreton District, South-Eastern Queensland.

By O. A. JONES, B.Sc., Research Student, Department of Geology, University of Queensland.

Plates VI.-VII., Text-figures 1-4, and two Maps.

(*Read before the Royal Society of Queensland, 28th April,* 1926.)

CONTENTS.

I.—INTRODUCTORY AND HISTORICAL.

The presence of Tertiary sediments in Queensland was for a long time suspected but unproven. A considerable development of Tertiary volcanics was recognised, but it is only in the last few years that the widespread and quite large deposits of Tertiary sediments have received any attention.

Numerous areas, some economically important, have now been discovered. These are mostly small, but several are of considerable extent, and the largest of these is that which has been designated "The Brisbane Tertiaries."

In 1883 Baron von Ettingshausen[1] described the Tertiary floras of Australia, but no Queensland specimens were included.

The first reference to Tertiary sediments in Queensland was by R. L. Jack[2] in 1892. He stated that "The presence of Tertiary rocks in

Queensland is rather inferred than proved." He, however, mentions some notes which were sent to him by H. G. Stokes, on the occurrence of Tertiary beds in the neighbourhood of Brisbane. Jack was inclined to regard the beds as part of the Ipswich formation, but left the whole question in abeyance pending the determinations of some fossils sent by Stokes to von Ettingshausen.

Ettingshausen[3] came to the conclusion that this flora as a whole indicated a Cretaceous age.

In 1898 Shirley[4] described some plants from the Oxley beds and criticised von Ettingshausen's paper, pointing out that many of the genera as determined by the Baron are represented in the existing Australian flora.

In 1899 W. E. Cameron's "First Report on the West Moreton or Ipswich Coalfield"[5] was published, but contained no reference to Tertiary strata. His second report,[6] 1905, however, mentions "an area of fissile shales which lie with a more or less distinct unconformity on the Bundamba series" at Redbank Plains. On the evidence of fish remains and dicotyledonous leaves he correlated them with the "supposed Cretaceous beds about Darra and Wolston."

In 1907 S. B. J. Skertchly[7] introduced the name "Brisbane Tertiaries" for beds occurring at Oxley, Darra, Sherwood, and Corinda. On the evidence of an unconformity and the fossil plants he assigned them to the Tertiary period. In a second paper[8] with the same title in 1908, he set out evidence of snow and frost action at Corinda and drew up a table showing the succession of strata.

E. O. Marks in his report on the "Coal Measures of South-East Moreton"[9] mentions the beds at Oxley, Cooper's Plains, Redbank Plains, and Runcorn, and stated that "Later opinion seems to favour their being ascribed to the Tertiary epoch."

In 1912 W. E. Cameron[10] increased the area of Post-Trias-Jura strata at Redbank Plains, as shown on his 1905 map, and designated it Cretaceo-Tertiary. In 1913 he wrote some notes on "Pre-Tertiary denudation of the Ipswich Coalfield"[11] in which he stated that mining at Dinmore and boring at Booval had demonstrated a considerable thickness of Post-Trias-Jura rocks lying unconformably on the coal measures.

In 1915 and 1916 boring threw further light on the Tertiary series, both as to lithological character and thickness; the Aberdare bore[12] passed through 955 feet of Post-Jurassic clays, shales, dolomites, and interbedded basalts.

In the geological appendix[13] to Harrap's Geography the Oxley leaf beds are included as Tertiary and described as sandy ferruginous clays occurring at Oxley, Redbank, Ipswich, Darra, &c. In the same year, 1916, Dunstan[14] described the Goodna Tertiaries and gave a diagrammatic section showing sandstones and shales with interbedded basalts lying unconformably on the coal measures. This was the first reference to the series by the Geological Survey as Tertiary, although Stokes as far back as 1892 had considered them to be of Tertiary age.

The next important development was in 1921 when W. E. Cameron,[15] on a map of the Ipswich coalfields, showed very much increased areas of Tertiary strata and, further, divided them into two series—the Redbank Plains series and the Silkstone series, with a total thickness of 1,200 feet.

Subsequently, in 1922, Reid and Morton[16] deleted considerable portions of these areas, removing them again to the Mesozoic series.

Early in 1925 C. C. Morton found a plant fossil—a dicotyledonous leaf, in almost vertical strata, about 1½ miles west of Strathpine, on the North Coast line. Further investigation has shown the Tertiary deposits in this area to be of considerable extent.

II.—AREAL DISTRIBUTION OF THE DEPOSITS.

Tertiary strata, as already mentioned, were first noted at Oxley and Corinda by Stokes. The Redbank Plains fish beds were discovered in 1905, followed by those at Dinmore and Ipswich in 1912.

The deposits fall naturally into two divisions:—

(1) The Oxley, Redbank, Ipswich beds, and

(2) The Bald Hills, Petrie, Redcliffe beds.

In 1913 Cameron[17] stated that the deposits covered on area of some twelve square miles; in 1921, before the discovery of the Petrie beds, he divided the Tertiaries into two series—the Redbank Plains series and the Silkstone series. These two series cover areas in all some twenty square miles; most of these areas belong to the Redbank Plains series, the Silkstone series being restricted to a small area about Silkstone and East Ipswich.

The largest development is a little to the east of Ipswich, both series occurring there. At Redbank Plains, Goodna, Oxley, and Cooper's Plains, extending to Corinda and Sherwood, occurs the Redbank Plains series. A small area is also located on the opposite side of the river at Moggill (opposite Riverview). There is a doubtful outcrop at Eight Mile Plains; at Runcorn, nearby, beds probably of this age have been met in a well drilled through basalt.

It is quite possible that these areas will be further extended in the future.

The Tertiaries in the Petrie-Redcliffe area (which I call here the Petrie series) were found to have a much greater extent than was at first suspected; they cover an area of some twenty-five square miles, the northern limit having not yet been fully determined.

The strata extend from Chermside to Zillmere and to Strathpine, to some five miles west of Strathpine, north to Petrie and eastwards to Redcliffe.

III.—DESCRIPTION OF THE VARIOUS OCCURRENCES.

Redbank Plains Series.

This is a series of sandstones, clays, and fissile shales, and contains fish remains, ostracods, dicotyledonous leaves, and petrified wood. Insects have also been recorded.

The series occurs around Oxley, Darra, and Cooper's Plains, at Redbank Plains, and at East Ipswich and Bundamba. Teleostean fish remains, mostly fragmentary, have been found at two localities—Redbank Plains, where they occur in ferruginous sandstones, and at Cooper's Plains in a soft white sandstone associated with innumerable ostracods and plant remains.

Around Oxley, Darra, and Cooper's Plains the beds consist of compact micaceous sandstones and clays; in places plant fossils are numerous.

Around Ipswich and Dinmore the strata are compact mudstones and sandstones; at Ebbw Vale in this area is a particularly rich plant horizon. On the north side of the river at Moggill is an occurrence of this series. It is similar in lithological characters to the Oxley beds and to the north-west it is overlain by basalt. Portions of the western part of this area mapped as "Tertiary" by Cameron consist of massive sandstones and are certainly of Triassic age.

At Corinda there occurs a very interesting set of rocks. They consist of boulder beds of considerable thickness. The best section is seen at Lahey's Sawmill at Sherwood. There huge boulders of quartzite-breccia (Plate VI., fig 1) may be seen; the largest of these measures 15 feet by 5 feet by more than 3 feet. Above these are boulder beds. The material ranges from pebbles to large boulders the size of a man's head. A large proportion of these are of igneous origin, the rest being mainly quartzite.

In addition to this section, outcrops occur in the watercourses around Sherwood and Corinda, and at Oxley and on the Brisbane-Ipswich road near Darra. (Plate VI., fig 2.)

The origin and age of these beds form an interesting problem.

Skertchly[19] in 1907 and 1908 suggested that they were Tertiary and considered that they originated by the action of snow and frost on the Palæozoic schists. He regarded them as the bottom of the Tertiary series, giving the following succession:—

Recent.—Alluvium of the Brisbane River in three terraces.

Tertiary—

Neogene—Olivine basalt; magnesite.

Eogene—

(1) Mottled red and grey marls and brickearth. . .
(2) Fine white sand with Carbonaceous markings.
(3) Plant beds; fine-grained whitish sandstone.
(4) Sandstones; not compact.
(5) Sherwood skerry scree.
(6) Higeldy gravels with erratics.

Mesozoic.—Ipswich beds.

All later writers except W. E. Cameron have regarded them as part of the Mesozoic series.

It has been suggested that the boulder beds (the skerry scree and erratics) represent recent or late Tertiary river deposits, and that quartzite-breccia boulders are Mesozoic and formed islands in the river. The fact that quartzite does occur in the Bundamba series supports this; but the quartzites are of a very different type, being fine-grained and having no large angular fragments.

On the whole I think the large boulders must be regarded as forming part of the smaller boulder beds and not part of a river bottom; they must, moreover, constitute the top, not the bottom, of the Cainozoic deposits. There is at present no satisfactory explanation of the origin of these huge boulders.

The rock types included in these deposits are of some interest, and descriptions of the more common are given below.

Quartzite.—This varies from a fine-grained quartzite to a coarse quartzite breccia, the fragments of which, mostly chert, are very angular. Most of the boulders exhibit a peculiar weathering; the surface shows numerous intersecting arcuate lines tending to circles of about $\frac{1}{6}$ inch in diameter.

Sandstone.—Sandstone derived from the Triassic series occurs rather uncommonly.

Rhyolite.—Specimens of Rhyolite with marked fluxion structure are not uncommon; they are usually very fine-grained, no minerals being seen in the hand specimen.

Trachyte.—Large pieces of trachyte, usually in a very weathered condition, are common. They vary somewhat in granularity. The coarser type is similar to some of the Peak Mountain trachytes, showing phenocrysts of augite and felspar in a very light-coloured groundmass. The fine-grained ones are more like the Glass House Mountains trachyte, needles of augite being very numerous.

Quartz Porphyry is also common. The groundmass is felsite with phenocrysts of quartz, felspar, and hornblende.

Orthoclase Porphyry.—A few specimens of this were obtained; the phenocrysts are pink orthoclase, and a few of quartz in a felsitic groundmass.

Radiolarian Jasper.—This is a deep red jasper, containing very numerous radiolaria, excellently preserved, and often to be seen with the unaided eye. It is similar to the radiolarian jasper found in the Brisbane Schist series at Fernvale.

Spotted Slate.—This is a bluish-grey clay slate with very numerous black spots of carbonaceous matter. It is probably an argillaceous rock metamorphosed by the Enoggera granite. Several specimens were obtained.

Greywacke.—This is a very coarse-grained rock consisting of a mosaic of quartz and felspar. Under the microscope it is seen to be principally felspar (both orthoclase and plagioclase, the latter with multiple twinning), which is very weathered, and quartz in subordinate amount.

All these rocks may have originated somewhere in the Upper Brisbane River valley, although the quartzite is doubtful. This supports the theory that the deposits are river gravels, but the origin of the huge breccia masses remains a mystery.

The Silkstone Series.

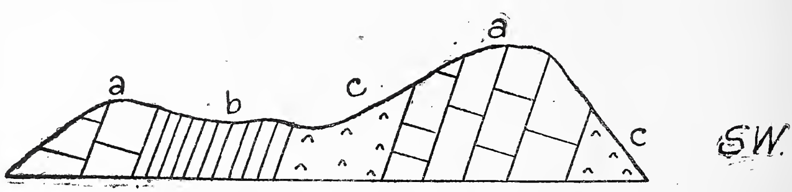
This name was given by Cameron[20] to strata occurring at Silkstone and East Ipswich, resting conformably on the Redbank Plains series.

The Series consists of clays, fissile shales, and sandstones with interbedded basalts and dolomitic limestones.

The largest outcrop of the limestone is at Queen's Park, Ipswich; it is rich in magnesia; it has been used for cement-making, but is of poor quality; in parts it is cavernous in structure, due to differential weathering. The top parts of the limestone beds have in places the appearance of siliceous limestone breccia.

A. M. Bateman[21] has shown that a replacement deposit may contain angular fragments, the replacement having proceeded outwards from intersecting veinlets; this is the explanation of the above breccia, really a pseudo-breccia; it is the replacement of limestone by silica derived from the basalt immediately above.

Opinion as to the origin of these limestones has been somewhat divergent. Thus R. L. Jack[22] considered the beds to be sedimentary and to have a steep dip to the north-east. He gave the following section[23]:—



TEXT FIG. I.

Section across Limestone Hill

a. Limestone. b. Shales. c. Basalt.

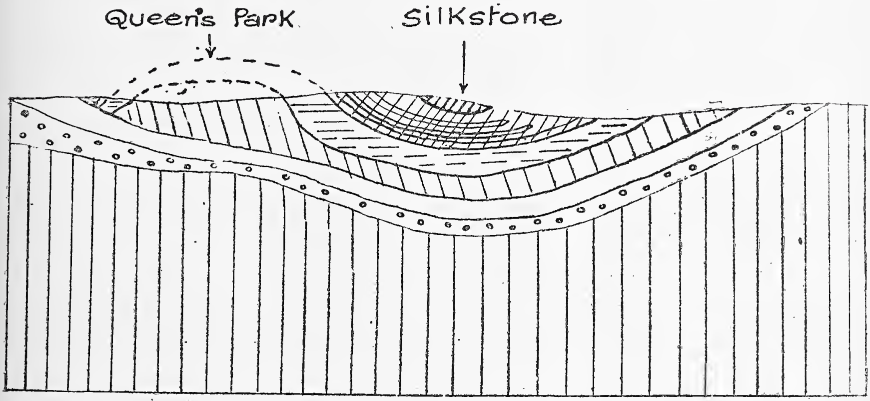
In 1894 W. H. Rands[24] noted a bed of "cherty magnesium limestone" at Pine Mountain (Esk Line), precisely similar to that at Ipswich, which he said "certainly belongs to the Ipswich series," and stated that unpublished investigations by Mr. Maitland had proved that the occurence at Ipswich was in reality the cap of an igneous dyke. Rands also stated that Jack had suggested that the lime and silica might be due to "concentration by segregation."

L. C. Ball[25] and H. I. Jensen[26] were also of the opinion that it was a secondary deposit due to the decomposition of an igneous dyke.

The sedimentary nature has now, however, been definitely proved by the finding of numerous specimens of a gastropod. They are poorly preserved, but all seem to belong to one genus—*Planorbis,* a freshwater gastropod ranging from Jurassic to present.

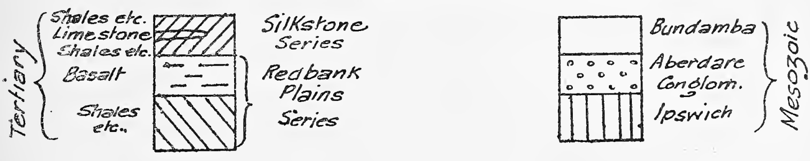
There appears to be but little evidence for the steep dips shown in Jack's section. This is the most disturbed portion of the Tertiaries, but the greatest dip recorded is 45°.

Cameron's[27] interpretation appears to be the correct one (Text fig. 2).



TEXT FIG. 2.

Section across Limestone Hill (Cameron)



Neither of these series (Redbank Plains and Silkstone) have undergone much folding; large areas are horizontal, and this would make it very difficult to determine their thickness were it not for information obtained from boring and mining operations.

The West Aberdare bore (portion 143, parish of Ipswich), put down in 1916 at Silkstone, gave the following record[28]:—

	Thickness in feet.	Depth of bore in feet.
Mudstones and shales	150	150
Dolomitic limestone	23	173
Vesicular basalt	44	217
Dolomitic limestone	51	268
Basalt (decomposed)	18	286
Marly clays	52	338
Basalt (vesicular in places)	481	819
Shales, mudstones, and soft sandstones	136	955

Triassic strata were then entered upon.

Another bore on Portion 148 gave a thickness of 394 ft. of Tertiary strata. This is wholly Redbank Plains series, rather less than 100 ft. at the top being basalt. This gives the thickness for this series as 300 ft.

Cameron[29] estimated the thicknesses of the two series as under:—

Silkstone Series—	
Clays, fissile shales and dolomitic limestones with interbedded basalt	400 feet
Redbank Plains Series—	
Vesicular basalt	500 feet
Fissile shales and sandstones	300 feet
Total	1,200 feet

The West Aberdare bore penetrated 338 ft. of the Silkstone series (to the bottom of the marly clays), but the bore is situated some distance up the eastern limb of the syncline; for the Redbank Plains series the thickness passed through was 481 ft. of basalt and 136 ft. of shales and sandstone; the lowest bed is, however, considerably thinner here than in many places, as for example at Queen's Park and on Portion 148, so that Cameron's estimates are essentially correct.

The Petrie Series.

This series was proved to be Tertiary in age only at the beginning of 1925, when C. C. Morton discovered a fossil dicotyledon. The area is of considerable extent—about 9 miles long, with a maximum width of about 7 miles, about 25 square miles in all.

The difference in the origin of these beds and those of the other series described above is strongly reflected in their lithological characters. The deposits around Oxley and Ipswich, which were derived chiefly from the erosion of the Mesozoic sediments, a small part from the Palæozoic metamorphics, consist almost entirely of fine-grained loose and moderately compact sediments; on the other hand the Petrie series, derived almost entirely from the Palæozoic schists, consist in the more westerly portions of ferruginous quartzite breccias (with a few beds of fine-grained sandstone); further to the east the fragments are more rounded, while at Redcliffe, the most distant from the schists, the strata are fine-grained micaceous white and red sandstones.

Quartzite boulders and pebbles are common on the surface of the series, and many of these show marked resemblances to "Billy"—a surface-formed quartzite of common occurrence in Western Queensland, especially on sapphire fields such as the Anakie. The "Billy" is commonly associated with Tertiary basalt flows and is sometimes stated to have been formed by the breaking up of sandstone beds (of any age) which were previously silicified by solutions derived from the overlying basalt. The association with Tertiary basalt holds in this area, for basalt occurs at Bald Hills.

At Redcliffe the strata consist of compact, fine-grained, white, micaceous sandstones. These are quite unfossiliferous. The sandstones are overlain by basalts, which form reefs running east and north-east into Moreton Bay.

Covering a considerable area around Strathpine and Petrie and near the water reserve on the Redcliffe road is a peculiar boulder deposit which has some features in common with that already described as occurring at Corinda (Plate VII., fig. 1). It differs from that at Corinda, however, in that the boulders are nearly all quartz or quartzite, the proportion of igneous material being low. The boulders are all sizes up to about 6 in. in diameter and well rounded. In some cases the deposits are fairly compact conglomerates; in others, only loose boulder beds.

Jensen[30] considers these to be recent shore-line conglomerates, an arm of the sea having stretched from Redcliffe to Strathpine. This theory would satisfactorily account for the Petrie deposits, but could not be applied to those at Corinda. Along the Pine Rivers and in the area between Sandgate and Zillmere the series is covered by recent alluvium.

As to the thickness of the Petrie series, it does not seem possible at present to make any estimate, owing to the almost complete absence of folding, and of bore records.

Other Areas.

Eight-mile Plains.—Outcropping at Eight-mile Plains and in the railway cuttings to the south-east of Kuraby are soft micaceous sandstones very similar lithologically to those at Oxley; they are overlain by basalt. No fossils have been obtained from them, but the tooth of a fish, *Ceratodus forsteri,* and part of a reptile, *Pallimnarchus pollens,* were mentioned by R. L. Jack[31] as having been found in a well sunk through the basalt at Runcorn. It is possible therefore that these may be outcrops of Tertiary strata.

IV.—IGNEOUS ACTIVITY; RELATIONSHIP TO TERTIARY VOLCANICS.

The Tertiary period was one of intense igneous activity in Eastern Australia.

Volcanic rocks are well represented in the areas under discussion, basalt overlying the sediments at Redcliffe, Bald Hills, Corinda, Cooper's Plains, Redbank Plains, Moggill, and Bundamba, while at Silkstone basalt flows are interbedded in the Silkstone series; at Redbank Plains extensive flows of spherulitic trachyte also rest upon the sediments.

The volcanic rocks of South-eastern Queensland have been fully treated by Professor Richards[32], who divides them into three series. All the abovementioned basalts are included in his uppermost division. As to the trachyte, Professor Richards thinks there is a definite connection between this and that along the line of eruption from Mount Flinders to the Main Range. These fall into the middle division, probably of Middle Tertiary age.

At Redbank Plains vesicular trachyte occurs also as a dyke. Steep dips are recorded a few yards to the west of the dyke, but near the dyke itself the strata are almost horizontal; the dyke itself is nearly vertical.*

The basalt at Redbank Plains exhibits several interesting features. Beneath it in several places occurs a bed of silicified limestone similar to that at Limestone Hill, Ipswich, but showing no trace of brecciation. The beds seem to be unfossilferous and may be due to the weathering and leaching of the basalt. Often with this limestone, and sometimes without it, is a peculiar green earth which also appears to be a weathering product of the basalt. This association of green earth and limestone is of especial interest, as Fermor and Fox[33] have noted between the lava flows of the Deccan in India a layer composed of (1) green earth, or (2) a silicified limestone often with freshwater fossils, or (3) both green earth and limestone. They considered the green earth to be an alteration product of the basalt.

Another alteration product of the basalt is bauxite. It is found as a mass in the basalt; it is a dirty white to yellowish-brown in colour, oolitic in structure, and very soft, crumbling in the fingers. In parts it retains the vesicular structure of the basalt. Zeolites occur in some of the steam vesicles.

A qualitative test showed the presence of a large quantity of aluminium. The material was ground, and dissolved in conc. hydrochloric acid; a very small residue was undissolved, thus showing the almost entire absence of silicates. The addition of ammonium hydroxide caused the precipitation of a white flocculent substance—aluminium hydroxide.

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* Dr. F. W. Whitehouse informs me that he has lately observed several of these dykes at Redbank Plains; some show very long phenocrysts of sanidine. Faulting is apparent nearby in every case.

The oolitic structure of bauxite masses has been responsible for the theories that they originated as sedimentary deposits or that they were replacements by hot solutions. The gradation from the bauxite into the igneous rock and the occurrence of minerals common to both proves the origin of the bauxite from the igneous rock. Leith and Mead[34] believe that the bauxite is developed in place by the action of percolating water, the oolitic structure being formed by a process similar to that producing concentric structure.

In the northerly extension of the Redbank Plains beds, towards Dinmore (along Six-mile Creek) is found an unusual spherulitic rhyolite. In the hand specimen it shows patches of deep-green material, sometimes with very sharp boundaries between it and light yellow-brown portions. In places the green gives way to red, due to oxidation. Some parts show numerous specks of silvery metallic pyrites.

The surface presents a very scoriaceous appearance, due in part to weathering, in part to the scoriaceous nature of the surface of the flow. Fluxion structure is present in many parts. Veins and masses of chalcedony are frequent.

Under the microscope the deep green parts are seen to be opaque green glass, while the brown material is devitrified glass. Spherulites occur in both the glass and devitrified glass. They consist mainly of quartz with some felspar. Fluxion structure is prominent.

V.—RELATIONSHIP TO OTHER SEDIMENTARY SERIES.

(1) *In the Oxley-Ipswich Area.*—The great similarity between the Tertiaries in this area and the underlying Ipswich and Bundamba series is shown by the fact that for many years they were regarded as parts of these series. This marked similarity is due, in great part, to their origin—they are composed mainly of material derived from the denudation of the Mesozoic series and were deposited under somewhat similar conditions, *i.e.*, lacustrine.

Stokes early indicated the presence of an unconformity between them, but this was not accepted at the time. It was not till 1913 that the presence of an unconformity was proved by mining and boring operations in the Ipswich district. This unconformity is further demonstrated by the overlap of the Tertiary series on to the Ipswich, Bundamba, and Walloon and Palæozoic series.

(2) *In the Petrie Series.*—The unconformity in this area is undeniable, for the series rests partly on the highly folded Palæozoic, and partly on the more gently folded Mesozoic (both Ipswicn and Bundamba).

At Petrie, in the Main Roads Board's cutting near the railway crossing, a faulted junction of the Brisbane schists and the Ipswich series may be seen. This is overlain by a loose conglomerate, which probably represents the most recent deposit in the area.

VI.—EARTH MOVEMENTS.

Treating the Tertiary movements for Australia in general, there are three outstanding facts which have been emphasised many times by E. C. Andrews[35]; these are (1) a general tendency in Australia and New Zealand to move in a vertical direction in Post-Cretaceous time; (2) that vertical movement was emphasised in an easterly direction, *i.e.*, during the progress of geological time folding movements in Australia retreated north and east; (3) the uplifts did not proceed continuously but were "saltatory" in their action.

That this tendency to vertical movement has been general throughout Eastern Australia, *i.e.*, that Eastern Australia was a geological unit in the Tertiary, has been a subject of some argument. The study of the Brisbane Tertiaries has thrown little light on the subject. In 1924 E. O. Marks[36] pointed out that if the Tertiary coastal deposits which are at sea-level, or very near it, should prove to have a similar flora and therefore a similar age to the deep leads of the Darling Downs, it would disprove the theory of a general uplift at the close of the Tertiary.

Turning now to Queensland itself, we have an important generalisation stated by Reid[37]—"the folded Tertiaries are confined to that part of Queensland between the 22nd and 28th parallels of latitude and to the east of the Beaudesert-Ipswich-Gayndah line (an important structural line of the folded Mesozoic)" This includes the area under consideration.

In general one may say that the strata are but little disturbed and large areas of horizontal strata occur as, *e.g.*, at Wolston (Redbank Plains series). For the most part the strata are gently inclined; occasionally quite steep dips are recorded, and in some places gentle folds occur.

(*a*) *Folding Movements.*—In the Ipswich district the Redbank Plains series and the Silkstone series have been folded into gentle anticlines and synclines with a strike of a few degrees west of north. In places the dips are as much as 45°. This folding is more nearly meridional than the Mesozoic folding.

In the Petrie series the only definite evidence of folding is to be seen on the Gympie road, about two miles south of Bald Hills. The fold is a syncline, the dip changing from about 30° north to the same amount south in a distance of about half a mile. The axis of the fold is approximately east-west.

(*b*) *Faulting Movements.*—Undoubted faulting occurs in several places. In the Bundamba-Ipswich area a considerable number of faults have been mapped from mining operations. They are mostly of comparatively small throw and their extent is usually not great. The strike varies considerably, but is usually a little west of north.

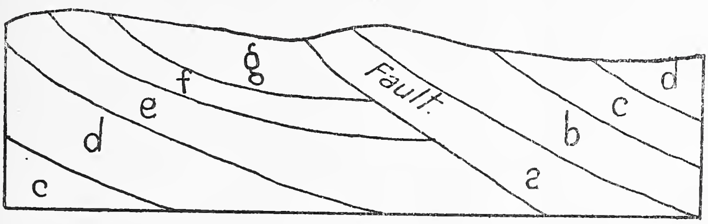
At Redbank Plains steeply dipping (up to 60°) strata occur; the steep dip is only local and is due to faulting. A few hundred yards to the west and parallel to this strata is another fault. The fish-bearing horizon is displaced vertically about 15 ft. The strike of these two faults is a few degrees west of north.

At Cooper's Plains evidence of faulting can be seen in the basalt quarry; the fault is a reversed one, and it strikes about 15° west of north.

In the railway cuttings around Oxley and Darra small faults may be seen in the Tertiary.

E. O. Marks[38] states that "In the bank of Oxley Creek it (the basalt) is either faulted against or fills a channel cut in them (the sediments)."

The Petrie Area.—Steeply dipping beds are known at several places in the Petrie area—at one and a-half miles west of Strathpine, where C. C. Morton found fossil leaves in almost vertical, fine-grained, biscuit-coloured sandstone; at a spot on the South Pine River about two miles south-west of Bald Hills (Plate VII., fig. 2), where a coal seam is included in the highly tilted strata (which has a width of about thirty yards); at a similar distance due south of Bald Hills. In the latter case it is definitely a reversed fault, a diagrammatic section being as under (Text fig. 3):—



TEXT FIG. 3

Diagrammatic section across steeply dipping Strata at Bald Hills

A further three-quarter of a mile to the south the strata again show large dips (about 50°).

In the first three cases the strike of the faults is about 10° west of north, in the last case it is slightly more to the west. We see therefore that the strike of all the Tertiary deposits varies but little from a few degrees west of north.

VII.—PALÆONTOLOGY.

(A) Plant Remains.

Fossil dicotyledons are found in many places, a few localities being particularly rich.

(1.) In the Redbank Plains series plants have been obtained from various localities around Oxley and Darra, in particular from (*a*)

Hurworth's quarry at Darra, where the fossils are preserved in a fine-grained micaceous sandstone, which splits irreguarly; (*b*) from the municipal quarry at Cooper's Plains, where the leaves are associated with fish and ostracods, in a soft sandstone overlain by basalt; (*c*) from Redbank Plains, associated with fish and insects in a highly ferruginous sandstone; and (*d*) from the clay pit of the Ebbw Vale pottery works. The last named is a particularly rich horizon. The fossils occur in dark-coloured shales and mudstones. This material crumbles easily and it is difficult to obtain good specimens. Through the shales occur numerous concretions of sandstone which are crowded with leaves excellently preserved. Beneath these are harder shales with numerous plants. The beds have a slight dip to the south-east.

(2.) In the Petrie series three leaves and what may possibly be a seed pod have been collected from an almost vertical bed of biscuit-coloured sandstone 1½ miles west of Strathpine. In spite of much search, no other specimens have been found anywhere in the area.

It is unfortunate that up to the time of writing no systematic attempt has been made to determine the complete flora. The work is, however, now proceeding.

In 1883 Baron von Ettingshausen[39] published the descriptions of Tertiary plants from various localities in Eastern Australia. Although no Queensland fossils were included, von Ettingshausen drew certain conclusions concerning the flora as a whole, which are of some interest. These conclusions were that the Tertiary flora of extra-tropical Australia is, as regards character, essentially distinct from the living flora of Australia, nor does it closely resemble in general any other living flora, but it is closely related to the Tertiary floras of Europe, North America, and the Arctic region.

These conclusions have met with considerable criticism from the various Australian workers.

In 1898 Shirley[40] described some fossil plants from Oxley and criticised von Ettingshausen's conclusions, pointing out that many of the genera as determined by the Baron are present in the existing flora. Several others criticised his conclusions along the same lines. It may therefore be stated that the Australian Tertiary flora does show affinities with the present-day Australian flora.

In 1893 von Ettingshausen[41] described a collection of fossil plants from the Redbank Plains series. As his work is not easily accessible and is in German, it is quoted extensively below.

"The fossils were gathered by H. G. Stokes from seven localities—

(1) Near Oxley Station,
(2) A street cutting at Oxley near the river,
(3) Railway cutting north from Oxley,
(4) Ipswich road opposite Darra Station,
(5) Near Oxley Creek,
(6) Sherwood near the railway station,
(7) Railway cutting between Darra and Oxley."

Ettingshausen came to the following general conclusions:—

"From the identifiable fossils of the collection, sixty-two species are classified as belonging to twenty-four orders and forty genera.

"All the chief divisions of the seed-bearing plants appear to be represented. With the exception of four species, all are new. These four belong to the Cretaceous. Of the new species thirty-one are comparable with Cretaceous species, with which they are more or less analogous, while only thirteen are quite analogous. Fourteen species have no definite analogies. The thirty-one Cretaceous species belong to the following genera:—*Thuites, Glyptostrobus, Cyperacites, Casuaranina, Myrica, Dryophyllum, Quercus, Fagus, Ficus, Artocarpidium, Cinnamomum, Diemenia, Laurus, Proteoides, Conospermites, Rhopalophyllum, Banksia, Aralia, Apocynophyllum, Diospyros, Andromeda, Ceratopetalum, Derbeya, Eucalyptus, Myrtophyllum,* and *Cassia.*

"Of the four old species, three are found in the Cretaceous in New Zealand and one in Europe.

"The thirteen analogous to the Tertiary species belong to the genera *Zosterites, Ceratophyllum, Fagus, Monimia, Grevillea, Banksia, Malpighiastrum, Elaeodendron,* and *Eucalyptus.*

"The species with no definite analogies belong partly to new genera as *Aulacolepis, Myricophyllum, Etheridgea, Podalyriophyllum,* partly to the families as *Leguminosites, Carpolithes, Phyllites.*

"According to the above facts the flora as a whole is Cretaceous in age.

"As to flora of the particular localities:—

Locality (1) gave 15 species—
- 10 analogous to Cretaceous.
- 4 analogous to Tertiary.
- 1 no analogy.

Locality (2) gave 12 species—
- 5 analogous to Cretaceous.
- 2 analogous to Tertiary.
- 5 no analogy.

Locality (3) gave 12 species—
- 7 analogous to Cretaceous.
- 3 analogous to Tertiary.
- 2 no analogy.

Locality (4) gave 19 species—
- 13 analogous to Cretaceous.
- 5 analogous to Tertiary.
- 1 no analogy.

Localities (5) and (6) were very poor in fossils; locality (5) one only recognisable, analogous to Cretaceous. Locality (6) gave only doubtful fossils or such as had no analogy. Locality (7) contains up to now sixteen species, eight analogous to Cretaceous and three to Tertiary; five show no analogy. Several species occur in two localities, two in three localities. Of those occurring in two localities, seven occur in locality (1), six of them are analogous to Cretaceous forms. In locality (2) only one occurs elsewhere and it is Cretaceous. In locality (3) five species occur elsewhere, of which two are Cretaceous. In locality (4) nine species occur elsewhere and six are Cretaceous; locality (7), four occur elsewhere and all are Cretaceous. The two species occurring in three localities are also Cretaceous.

"Taking the flora locality by locality the facts again prove them to be Cretaceous.

"From this survey of the species one concludes definitely that the Cretaceous flora of Australia shows a striking likeness to that of Europe, of the Arctic zone of North America and of New Zealand, also to all the well-known Cretaceous floras."

This conclusion that the flora is Cretaceous in age is open to the same objection as his earlier paper, namely that he failed to recognise that many of the above genera are represented in the present-day flora. It is now always regarded as Tertiary in age.

Petrified wood is of common occurrence in the Redbank Plains series. Birbal Sahni[42] has described specimens from Wolston as *Pataoxylon porosum sp. nov.*—a dicotyledon.

In the Petrie series plant remains have been found at one locality—1½ miles west of Strathpine. The horizon is a fine-grained biscuit-coloured sandstone and dips steeply. Three leaves and possibly a seed pod have been found; these have not yet been described.

(B) Animal Remains.

(1) *Invertebrates*—

Ostracods have been found at two localities, both in the Redbank Plains series. There are (1) at Redbank Plains in a gully on Portions 118, 119, and 120 Parish of Bundamba in a very fissile brown shale. The ostracods are numerous small oval bodies. (2) In the municipal quarry at Cooper's Plains, beneath the basalt is a soft fine-grained sandstone. In it are found fish remains, plants, and numerous small bodies. These differ from those at Redbank Plains in that they are round, not oval. The sandstone is of two types—a very light-coloured and a dark-coloured almost black sandstone.

Specimens from both localities have been sent to F. Chapman in Melbourne, but no descriptions have yet been received.

Insecta.—Insects occur in considerable numbers at Redbank Plains, in the same bed that contains the fish and leaves. Two of them, *Euporismites balli* and *Scolypopites bryani,* have been described by Tillyard.[43] They both show resemblances to present-day forms.

Gastropoda.—Gastropods occur in great numbers in parts of the limestone at Limestone Hill, Ipswich, a part of the Silkstone series. The gastropods are numerous but poorly preserved. They all appear to be similar, belonging to the genus *Planorbis,* a freshwater gastropod ranging from Jurassic to present. The finding of these numerous gastropods definitely proves the limestone to be a freshwater sediment.

(2) *Vertebrates*—

Fish.—Fish remains have been found in the Redbank Plains series at two localities—Redbank Plains and Cooper's Plains. At Cooper's Plains the fish are associated with ostracods and leaves in sandstone. At Redbank Plains they occur in the same bed as the insects and leaves—a very ferruginous sandstone. The fauna is rich but, unfortunately, no descriptive work has been attempted.

A tooth of *Ceratodus forsteri* was recorded by Jack and Etheridge, from a well in the basalt at Eight-mile Plains. The fossil was found at depth of about 70 ft. This may be Tertiary strata. The tooth was associated with plant remains and *Pallimnarchus pollens.*

Reptiles.—Reptilian remains have been discovered at two localities; *Pallimnarchus pollens* at Eight-mile Plains in the well mentioned above; and fragments of an angular from the left ramus of a reptilian mandible tentatively referred to *P. pollens*[44] have been collected from Redbank Plains close to the ostracod horizon.

Tortoise Remains.—Small fragments from the carapace and plastron of a freshwater chelonian apparently identical with *Chelodina insculpta* De Vis[45] have been found in alluvium in the gully in which ostracods occur at Redbank Plains.

We see therefore that a flora and fauna, both rich, are awaiting investigation.

VIII.—CLIMATE.

There is very little evidence bearing on the climate at the time of deposition of these sediments. The little evidence available suggests a climate not dissimilar to that at present. Maiden[46] regards some of the plant fossils as Eucalypts and we have seen that many other living genera are represented.

Sahni has described a Tertiary wood, *Pataoxylon porosum* from Wolston (Redbank Plains series). It is a dicotyledon, and Sahni says the preponderance of tracheides as the chief conducting elements is an unusual feature possessed by a few Magnoliaceous genera at the present.

Of the two insects described by Tillyard from Redbank Plains, *Euporismites balli* shows affinities to *Porismus strigatus* and *Euporismus* *albatrox*. The former inhabits dry or moderately dry places; it is fairly common in East Australia at the present time. The latter is very rare, being confined to South-west Queensland. The other insect described, *Scolypopites bryani,* is closely allied to the present-day *Scolypopa australis,* an insect very common in Queensland and the warm parts of New South Wales.

This scanty evidence indicates, if anything, a climate somewhat similar to the present.

Skertchly[47] considered the boulder beds around Sherwood and Corinda to be due to snow and frost action; this would indicate a considerably colder climate than the present. Although this is a possible explanation, the evidence is not very strong.

A glacial origin has been suggested for "Billy"[48] and, as we have seen, much of the quartzite in the Corinda beds and in the Petrie series shows strong resemblances to "Billy."

On the whole, we may say that there appears to be little evidence opposing a climate similar to the present.

IX.—AGE.

Stokes recognised the unconformity between the Oxley beds (Redbank Plains series) and the underlying Mesozoic series, and on this account and on the evidence of the flora ascribed to them a Tertiary age. Von Ettingshausen, however, thought the flora indicated a Cretaceous age, but did not recognise the large number of living genera. The fauna also is indicative of a Tertiary age, and Stokes's view is now the commonly accepted one.

At Redbank Plains vesicular trachyte occurs in the Tertiary beds. This has been shown to be a dyke; it probably belongs to Professor Richards' middle division of volcanic rocks which are probably of middle Tertiary age. The dyke, therefore, suggests a lower or middle Tertiary age for the sediments.

The Redbank Plains series is overlain at several places by basalts of the upper division, probably of Upper Tertiary age. This indicates a lower or middle Tertiary age.

At Redbank Plains the series is overlain by trachyte of the middle division; the age therefore must be lower or early middle Tertiary.

The Silkstone Series.—This series rests conformably on the Redbank Plains series; the only fossils recorded are of the gastropod *Planorbis sp.*, which ranges from Jurassic to present. This is only of value in that it places it post-Ipswich, of which series Jack thought it was a part. Interbedded basalt flows of the upper division occur and indicate an Upper Tertiary age.

The Petrie Series.—That this series is post-Triassic is shown by the fact that it rests unconformably on the Brisbane schist, Ipswich and Bundamba series. The only fossils found to the present are a few plant remains which are similar to those found in the Redbank Plains series.

The series is overlain at Redcliffe and Bald Hills by upper division basalts and by recent alluvium along the Pine River. Around Strathpine and Petrie boulder beds occur. As already mentioned, Jensen regarded these as recent shore-line conglomerates. In places they are quite compact and it may be that they are rather older than this. They are certainly the youngest of the Cainozoic deposits.

As is seen the evidence is rather fragmentary, but the age of the various series may be tentatively put as under:—

Silkstone Series	Upper Tertiary
Redbank Plains Series ..	Eocene or Oligocene
Petrie Series	Tertiary

The fuller investigation of the fauna and flora should go far towards fixing the age more definitely.

X.—CORRELATION WITH OTHER TERTIARY DEPOSITS.

Freshwater deposits of Tertiary age are widespread in Queensland, but the occurrences are mostly small in area.

The most important of these formations are:—

(*a*) The Brisbane Tertiaries—those described above, and the Beaudesert Tertiaries.

(*b*) The Tertiaries of the Rockhampton-Gladstone district.

(*c*) Winton series (Cretaceo-Tertiary of the artesian basin).

The Tertiary of the Rockhampton-Gladstone district comprise the Duaringa series (Duaringa, Lowmead, Baffle Creek, and The Narrows), the Nagoorin lignites and the Waterpark Coal series.

The Redbank Plains series of the Brisbane Tertiaries show many resemblances to these.

L. C. Ball[49] states that the Lowmead strata are lithologically like those at Oxley, while Dunstan[50] makes a similar statement about those at Duaringa. There are also resemblances in the flora and fauna. Dicotyledonous leaves, Unios, ostracods, and fragments of the carapace of tortoises occur at Lowmead, as also in the Redbank Plains series. On the other hand, the occurrence of gastropods, which Ball says most nearly approach *Planorbis,* may suggest a correlation with the Silkstone series. *Planorbis,* however, ranges from Jurassic to present, so this has not much weight.

Ostracods and plant remains similar to those at Oxley occur in The Narrows Tertiary oil shales.

Fish remains, leaves, and insects occur in the Duaringa series and, as Dunstan[51] states, the fish in particular may serve as a connecting link with the Brisbane Tertiaries.

We have already noted that the "Billy" series seems to be represented both in the Redbank Plains series and the Petrie series. Thus it would seem probably that when the various faunas and floras have been worked out in detail the work of correlation will not be very difficult.

XI.—ECONOMIC.

The Tertiary series is of little economic importance except in the matter of clays, in which it is very rich.

Clay.—There is an abundance of excellent clays in the Redbank Plains series, and it is extensively used for making bricks, pipes, and other earthenware and in the manufacture of cement. In the Petrie series there is a good development of clay, particularly along the North Pine River. H. I. Jensen[52] described this in 1918; he regarded the whole of the Tertiary series as a lateritic capping of the Brisbane schists. Clay is also abundant along the south Pine River. These deposits have not yet been utilised.

Oil.—A bore for oil was sunk at Wolston in the Redbank Plains series, but was quite unsuccessful; as the strata are horizontal it was not to be expected that oil would be found here.

The general absence of suitable structure in the Tertiary series precludes any possibility of the discovery of oil in them.

Coal.—On the bank of the South Pine River a seam of coal outcrops in steeply dipping strata. It is unlikely to be of any great value.

Diatomaceous Earth.—A thin bed of this material occurs to the south of Bald Hills. The outcrop is in steeply dipping strata. An analysis showed 93 per cent. silica, but there does not appear to be a sufficient quantity for it to be of value.

Road Metal.—A sandstone belonging to the Petrie series has been used by the Main Roads Board as the base of the Brisbane-Redcliffe road.

Bauxite.—Bauxite occurs in the basalt at Redbank Plains, but only in small amount.

XII.—CONCLUSION.

In conclusion it may be said that although some work has been accomplished, there still remains much to be done, especially on the Palæontological side.

Thanks are due to Professor Richards, Dr. Bryan and Dr. Whitehouse for the encouragement given and the interest taken in the work, and to Mr. Morton of the Queensland Geological Survey for assistance in a part of the field work.

APPENDIX.

Notes on Supposed Tertiary Strata to the North, North-west, and South-west of Ipswich.

The areas above referred to were shown as Tertiary by Cameron in his map[53] of the Ipswich coalfield, 1921. Later Reid and Morton[54] deleted much of these areas, removing them to the Mesozoic. Investigation of these areas has supported Reid and Morton's conclusions and has shown that none of them are of Tertiary age.

I. The Area to the South-west of Ipswich, extending West to Rosewood and South towards Flinders and Harrisville.—This area proved to belong to the Walloon series. Typical Walloon fossils have been found in several widely separated parts of the area—two and a-half miles west of Purga, Flinders railway station, and about four miles west of Peak Crossing. The list of those found near Purga (now in the University or Queensland Geological Museum) is as follows:—*Cladophlebis australis* (very numerous), *Dictyophyllum rugosum, Brachyphyllum, Osmundites, Sagenopteris, Araucarites, Taeniopteris spatulata.*

The matrix is a highly ferruginous gritty sandstone.

The presence of *Taeniopteris spatulata,* the prominence of *Cladophlebis australis,* and the nature of the whole suite of fossils is definite proof of the Walloon age of the strata.

The writer has collected limestone showing cone-in-cone structure just to the south of Purga, and Dr. Bryan has collected it near Flinders. This cone-in-cone limestone is very typical of the Walloon series. In the western part of the area are many outcrops of soft white and yellow sandstones—typical Walloon sandstones. Some of these are very calcareous. As shown by Jensen,[55] the *lower* Walloon is largely calcareous sandstone; the presence of cone-in-cone limestones and calcareous sandstones points to a lower Walloon age for this area.

The only evidence in favour of a Tertiary age is the occurrence in a well near Loamside of very soft fissile shales.

Correlation on lithological characters alone is of comparatively slight value and this evidence is far outweighed by the fossil evidence and typical structure of the limestones.

II. The Area to the North and North-west of Ipswich.—This extends from West Ipswich in a north-westerly direction through Pine Mountain to Fairney Lawn. An examination of this area has shown the "Tertiary" of Cameron to belong in part to each of the three Mesozoic series. This conclusion was reached by Reid and Morton[56] in 1922.

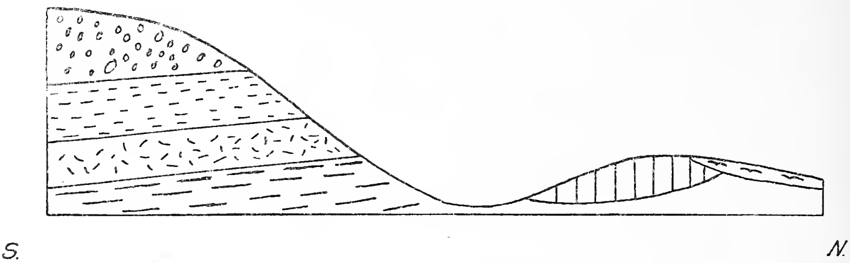
All that portion lying to the north, to the east, and immediately to the south of the Pine Mountain schist belongs to the Ipswich series; it consists almost wholly of conglomerates—the basal conglomerates of the Ipswich series. Outcrops are numerous and typically Ipswich. Ipswich fossils (*Thinnfeldia*) were found by Reid and Morton in Por. 364, 365, Parish of Brassal (to the south of Pine Mountain).

To the west of Pine Mountain the strata is Ipswich in age, as shown by Cameron. To the west of this is a strip of Bundamba series, running from Glamorgan to Ipswich and further south. This includes the majority of the strata mapped by Reid and Morton as Borallon series. It also includes much of Cameron's Tertiary and some shown by him as Walloon. Throughout this strip there are numerous outcrops of sandstone of Bundamba type.

Immediately to the north-west of Ipswich the strata are of Walloon age, the many outcrops being of soft sandstone. This is continuous with the area described in I.

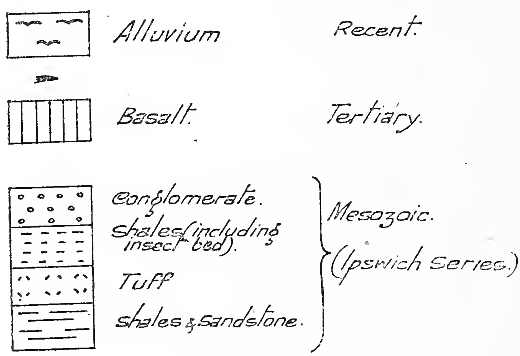
III. The Mount Crosby Area.—On the Brisbane River opposite to Mount Crosby, Cameron marked a small patch of Tertiary, in part overlain by basalt extending across the river.

This has proved to be part of the Ipswich series.



TEXT FIG. 4.

Diagrammatic section of strata on Brisbane River opposite Mt. Crosby.



In descending order we find the following beds (*see* Text-fig. 4) :—

Massive Conglomerates.—The basal conglomerates of the Ipswich series.

Shales.—Very fissile, about 15 feet thick, containing *Thinnfeldia odontopteroides, Taeniopteris dunstani, T. tenison-woodsi, T. lentriculeforme, Baiera tenuifolia, Baiera* sp., *Cladophlebis australis,* one of the equisetales, and a number of insect wings, mostly fragments.

Volcanic Tuff.—A dark-greenish tuff, seen in thin section to be similar to the Brisbane tuff.

Shales.—Similar to those above the tuff, with beds of sandstone, silicified and with numerous veins of calcite. *Taeniopteris dunstani,* and *T. tenison-woodsi* were found both in the sandstone and the shales. Some of the sandstone shows ripple marks.

All the strata show a slight dip to the south.

Notes on the Beaudesert Tertiary.

Tertiary strata were discovered on the Logan River near Beaudesert in a bore for oil in 1924. There are several references to this discovery in the "Queensland Government Mining Journal" for 1924 and 1925.[57]

In October 1924 S. C. Ball[58] stated that there was 100 feet of alluvium and at least 80 feet of Tertiary strata.

The Tertiary beds contain ostracods, small freshwater gastropods (*Melania sp.* Cretaceous to present), and pelecypods.

An examination of the country between Brisbane and Beaudesert, Redbank Plains and Beaudesert, and beyond Beaudesert has failed to reveal any outcrops of these beds.

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58. Q.G.M.J. Oct. 1924.

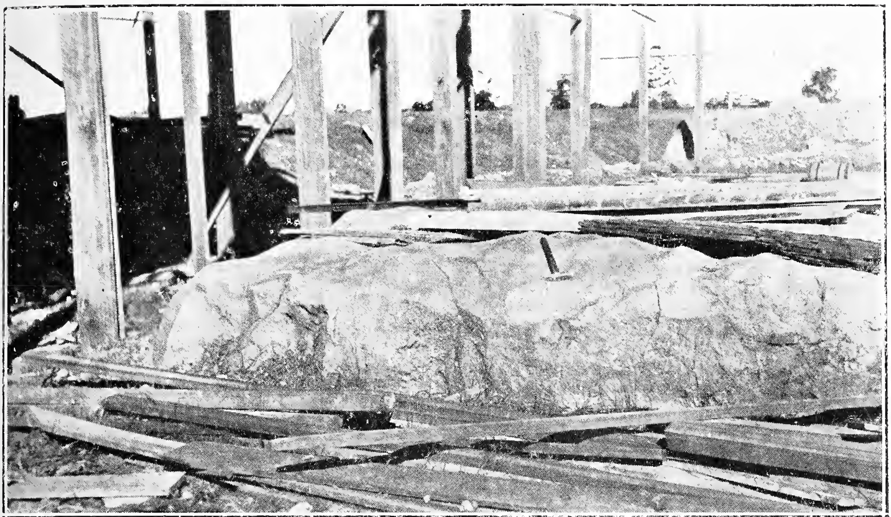


Fig. 1.—Large boulder of quartzite breccia, Lahey's Mill, Corinda. Boulder beds in the background. Redbank Plains series.

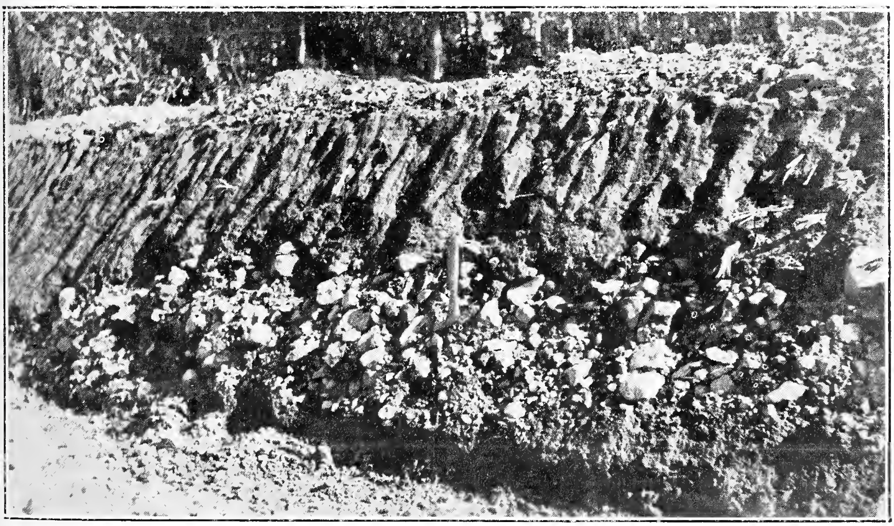


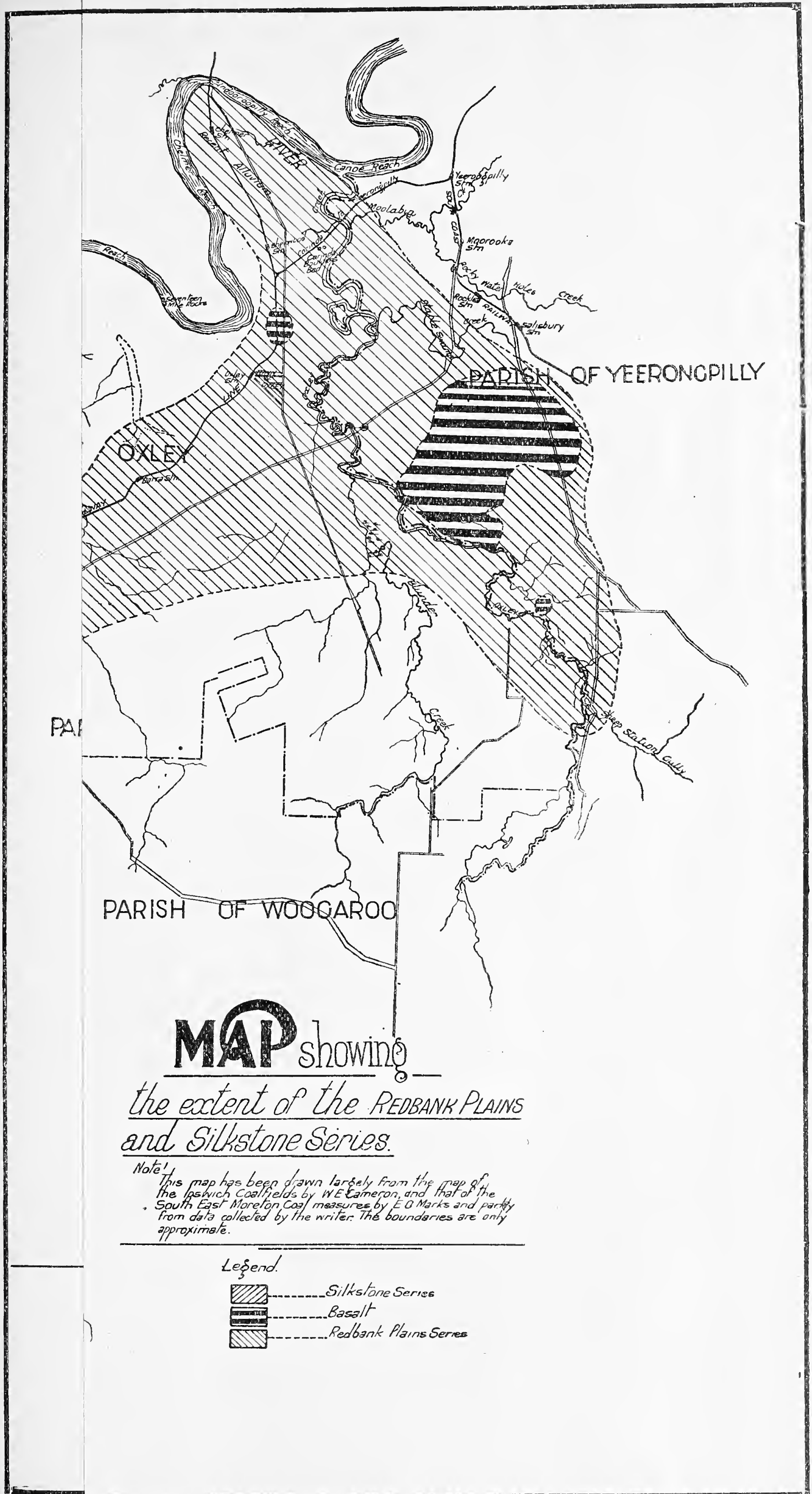
Fig. 2.—Boulder bed in clay on the Brisbane–Ipswich road, near Darra. Redbank Plains series.

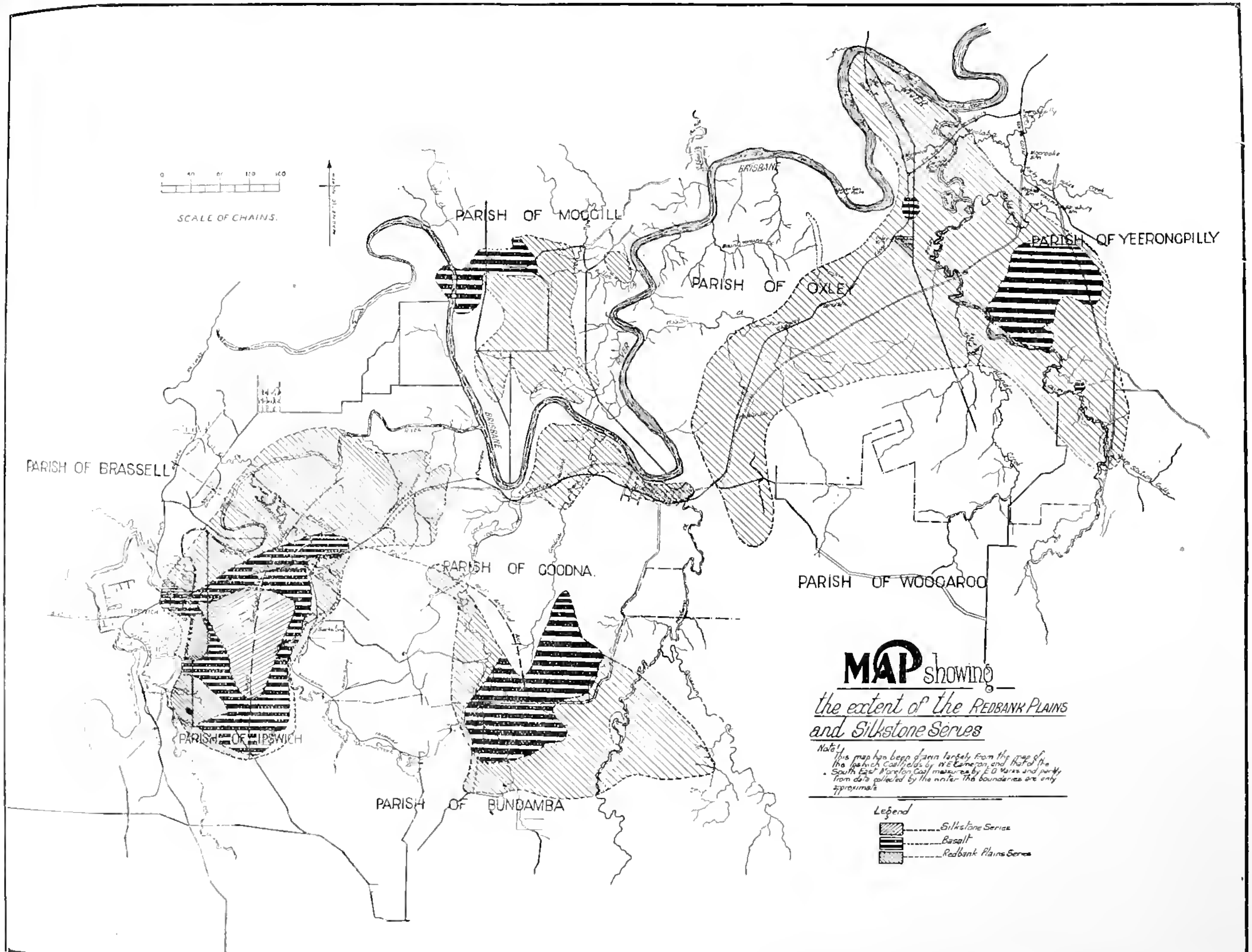
[*Face page* 46.]

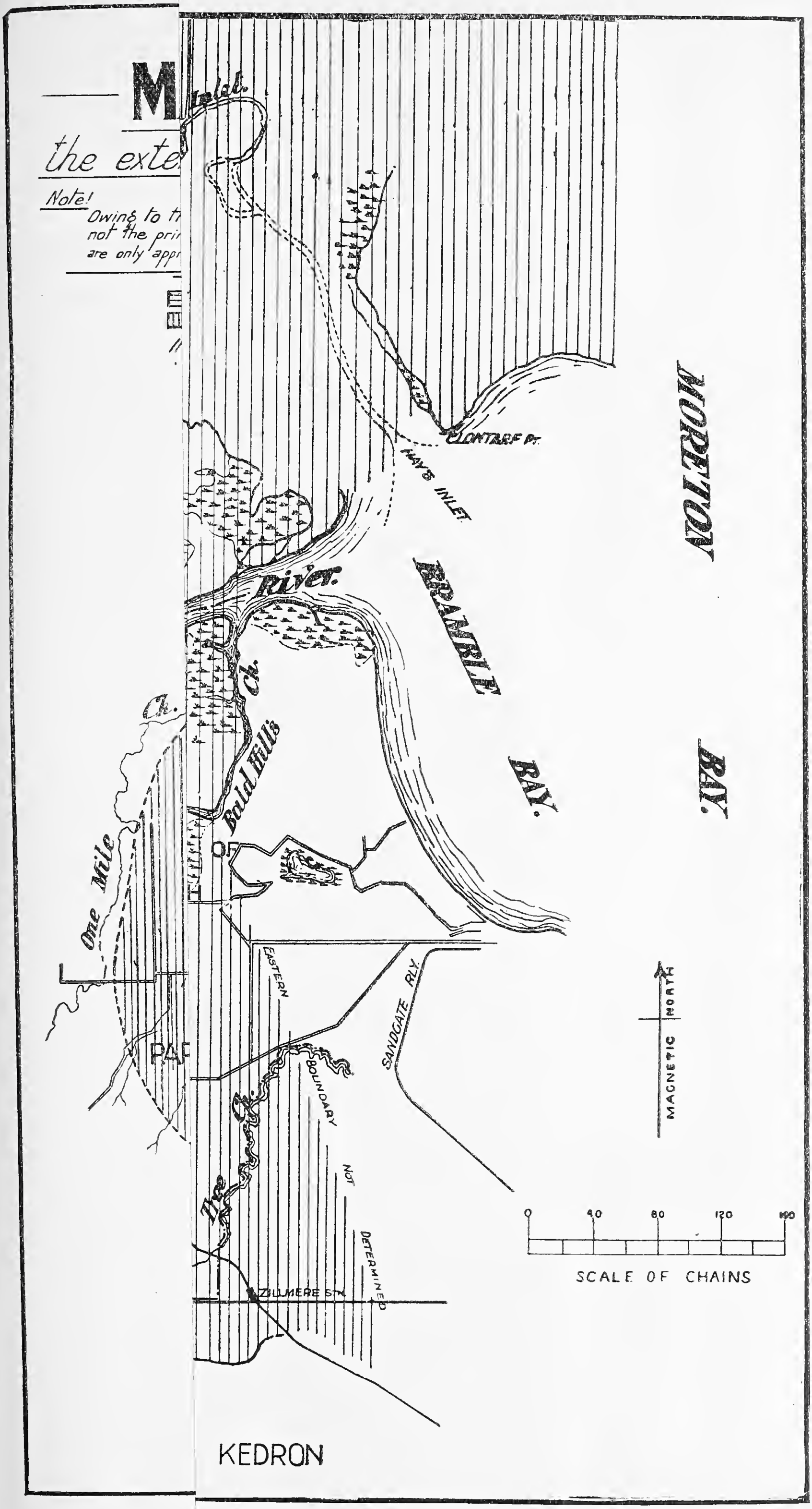
Fig. 1.—Boulder bed on Brisbane-Redcliffe road. Petrie series.

Fig. 2.—Steeply-dipping strata, including coal seam, South Pine River.

[*Face page* 46.]


PARISH OF YEERONGPILLY
OXLEY
PARISH OF WOOGAROO
Yeerongpilly Stn
Moorooka Stn
Rocklea Stn
Salisbury Stn
Canoe Reach
Moolabin
Rocky Water Holes Creek
Sheep Station Gully
Seventeen Mile Rocks
MAP showing
the extent of the Redbank Plains and Silkstone Series.
Note!
This map has been drawn largely from the map of the Ipswich Coalfields by W.E. Cameron, and that of the South East Moreton Coal measures by E.O. Marks and partly from data collected by the writer. The boundaries are only approximate.
Legend.
Silkstone Series
Basalt
Redbank Plains Series


MAP showing
the extent of the Redbank Plains and Silkstone Series
Note!
This map has been drawn largely from the map of the Ipswich Coalfields by W.E. Cameron, and that of the South East Moreton Coal measures by E.O. Marks and partly from data collected by the writer. The boundaries are only approximate.
Legend
Silkstone Series
Basalt
Redbank Plains Series
SCALE OF CHAINS.
PARISH OF MOGGILL
PARISH OF YEERONGPILLY
PARISH OF OXLEY
PARISH OF BRASSELL
PARISH OF GOODNA.
PARISH OF WOOGAROO
PARISH OF IPSWICH
PARISH OF BUNDAMBA
BRISBANE



the exte
Note!
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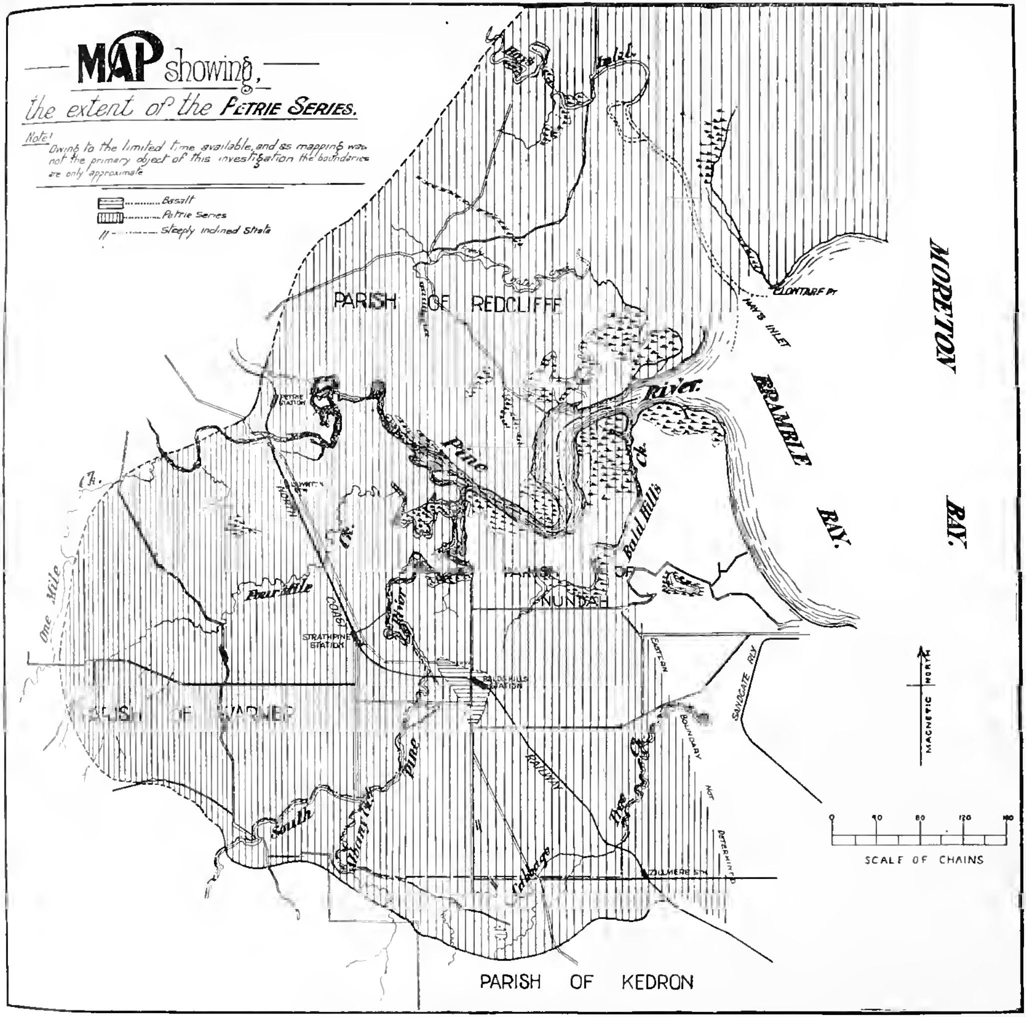
are only appr
MORETON
BAY.
BRAMBLE
BAY.
River.
HAYS INLET
CLONTARF PT.
Bald Hills
Ch.
One Mile
EASTERN
BOUNDARY
NOT
DETERMINED
SANDGATE RLY.
ZILLMERE STN
MAGNETIC NORTH
0
40
80
120
160
SCALE OF CHAINS
KEDRON


MAP showing,
the extent of the Petrie Series.
Note! Owing to the limited time available, and as mapping was not the primary object of this investigation the boundaries are only approximate
Basalt
Petrie Series
Steeply inclined Strata
PARISH OF REDCLIFFE
PARISH OF NUNDAH
PARISH OF WARNER
PARISH OF KEDRON
MORETON BAY
BRAMBLE BAY
CLONTARF PT
HAYS INLET
Inlet
River
Pine
Bald Hills Ck.
Four Mile
One Mile
South Pine River
PETRIE STATION
STRATHPINE STATION
BALD HILLS STATION
SANDGATE RLY
COAST
RAILWAY
BOUNDARY NOT DETERMINED
MAGNETIC NORTH
0 40 80 120 160
SCALE OF CHAINS

Variation of the Acclimatised Species of Prickly-pear (*Opuntia.*)

By W. B. Alexander, M.A., late Officer in Charge of Prickly-pear Investigations, Commonwealth Prickly-pear Board.

(By permission of the Board.)

(Plates VIII.–X.)

(*Read before the Royal Society of Queensland, 28th April,* 1926.)

I.—INTRODUCTORY.

Of the species of the American genus *Opuntia* acclimatised in Australia, nine have established themselves so securely as to be regarded as pests, and two of these cover enormous areas of country. The vast numbers of plants growing in a country new to them under conditions different from those of their native land, in a great variety of soils, and, in the case of the most widespread pest (*O. bentonii,* Griff.), under great differences of climate, might be expected to vary correspondingly. This expectation might be held even more strongly when it is considered that in their monograph of this genus, published in 1919, Drs. Britton and Rose described 240 species and added nine more in a supplement published in 1923. The estimate of these authors is undoubtedly a conservative one, very many species considered distinct by other students of these plants being relegated by them to synonymy. This fact in itself would indicate that the authors regarded the species of *Opuntia* as essentially variable. Some account of the actual variations met with by the writer among the species acclimatised in Australia during over four years of study may therefore be of interest, for in this continent the species found in any locality are so few that it is possible to decide with very little hesitation as to the origin of any variety met with.

The species acclimatised in Australia have been described and illustrated in a booklet published by the Commonwealth Prickly-pear Board, in the preparation of which the writer received valuable assistance from Mr. C. T. White, F.L.S., Government Botanist of Queensland. Those classed as pests were identified as follows:—

1. Common Pest Pear (*Opuntia bentonii,* Griff. = *O. inermis,* D.C. var.) established over some 47,500,000 acres in Southern Queensland and Northern New South Wales, and over great areas growing so densely as to be impenetrable.

2. Spiny Pest Pear (*O. stricta,* Haw.) spread over about 1,000,000 acres in Southern Central Queensland, in the watersheds of the Fitzroy and Burnett Rivers, often growing so densely as to be impenetrable.
3. Tiger Pear (*O. aurantiaca,* Lindl.) acclimatised in many areas in Northern New South Wales and Southern Queensland.
4. Smooth Tree Pear (*O. vulgaris,* Mill. = *O. monacantha,* Willd.) established in many localities in the coastal districts of all the Australian States.
5. Velvety Tree Pear (*O. tomentosa,* Link.) established in numerous localities in Queensland and a serious pest in parts of the Fitzroy and Dawson Districts, where some of the brigalow scrubs are quite impenetrable owing to its presence.
6. Devil's Rope (*O. imbricata,* D.C.) established in numerous localities in Northern New South Wales and at one or two places in Southern Queensland.
7. Cardona (*O. streptacantha,* Lem.) acclimatised about Rockhampton and at scattered localities for 150 miles west of that city.
8. Joconoxtle (*Opuntia* sp.) established about North Rockhampton.
9. Dark-spined Pear (*O. elatior,* Mill. = *O. nigricans,* Haw.) established near Denman in the Hunter district of New South Wales.

The writer has met with no variations in *O. aurantiaca, O. vulgaris, O. streptacantha,* and the Joconoxtle other than such as were obviously due directly to greater or less suitability of the situation in which the plants were growing.

The variations met with among the other species will be grouped under the heads of:—Fluctuations, Mutations, and Hybrids.

II.—FLUCTUATIONS.

The development of spines in *O. bentonii* and *O. stricta* and to a less extent in *O. tomentosa* and *O. elatior* depends to a considerable degree on the situation in which the plant is growing.

In the open and in poor soil spine development is at its maximum, whilst in good soil in the shade of bushes and trees *O. bentonii* is practically always spineless and *O. stricta* produces very few spines.

In these contrasted situations the form of the individual joints is also considerably modified. In the open and in unfavourable soils they are thick and comparatively short, sometimes subcircular in *O. bentonii,* whilst in deep shade they are thin and elongated.

That these differences are correctly regarded as fluctuations due to environment can readily be shown by transplanting spiny plants from an unfavourable environment to sheltered situations. The new shoots produced at once take on the form proper to their new environment. This is clearly shown in the accompanying photograph of a plant of *O. stricta* transferred from the open to a dimly lighted enclosure (Plate VIII.). If kept in a very subdued light for a prolonged period all the species of *Opuntia* produce very long, cylindrical, or strap-shaped joints, and these may sometimes be seen on plants of *O. bentonii* growing beneath a thick bush of *Lantana*.

It is the great variability in form and spininess of the joints which sometimes leads to confusion between the two principal pest pears of Australia, but to anyone familiar with the fluctuations of the two species there is no difficulty in distinguishing them under any circumstances.

III.—MUTATIONS.

Under this heading I am including all those variations which do not appear to be due directly to environment.

In the Velvety Tree Pear, *O. tomentosa*, a certain proportion of the plants are very much more spiny than the majority. The spines are both more numerous and considerably longer, and their white colour contrasting with the dark green pubescence of the joints gives these spiny plants quite a distinctive appearance. Probably about 5 per cent of the plants in Central Queensland are spiny and the variation is well marked in the seedling. It is true that occasionally intermediate plants may be found with a moderate development of spines, but these are far less common than the extremely spiny form. It seems almost certain that in this species spinelessness and spininess are Mendelian characters.

At Glenmore, North Rockhampton, are growing a number of plants of cultivated species of *Opuntia* from the province of Zacatecas, Mexico. Seeds of these plants were brought by the late Mr. Birkbeck from that country over seventy years ago. Among them are four which seem to be essentially the same species but differ in two pairs of characters—red or white fruit and spiny or spineless joints. They are known in Spanish as Tuna colorada espinosa, Tuna colorada sin espinas, Tuna blanca espinosa, and Tuna blanca sin espinas.

Here again we meet with spinelessness and spininess acting as if they were Mendelian characters.

It is perhaps as well to emphasise that "spinelessness" is used here as a relative rather than an absolute term. It is doubtful whether any entirely spineless *Opuntia* exists. Those commonly called "spineless" are species on which the spines are generally few and often disappear altogether from the older joints.

The pest pear of South Africa exists in spineless and spiny forms, known to the inhabitants respectively as "kaalblad" (cabbage-leaf) and "doornblad" (thorn-leaf). Both are regarded as forms of *O. ficus-indica* or a closely related species.

At Gravesend, New South Wales, there is a plant of *O. imbricata* growing in a garden which is markedly less spiny than the plants commonly met with. This is perhaps the "spineless" form of this species, though its spinelessness is very far from complete. I have not myself seen this plant, but Mr. F. H. Roberts, M.Sc., showed me specimens obtained from it. It is possible that it is only a fluctuation produced by garden conditions, but I have seen other plants of this species in gardens with normal spininess.

Opuntia bentonii, our common pest pear, is apparently a fixed "spineless" species. Occasionally it produces as a bud variation an extraordinary spiny form which bears a great resemblance to *O. dillenii*, Ker-Gawler, and is certainly responsible for some of the records of the occurrence of that species in Australia. This spiny mutation of *O. bentonii* differs from the normal form in a number of features, not merely in the development of spines, so that it cannot be grouped with the simple mutations referred to above. The joints are spatulate or elongate obovate and at least twice as long as they are broad, whereas in the normal form they are broadly obovate and the breadth is usually considerably more than half the length. The areoles are usually less than an inch apart, six or seven in a diagonal line across the joint, whereas in the normal form they are an inch apart and only three or four occur in a diagonal line across the joint. But it is the armature of the areoles which is the most striking feature. Each bears a large number of flattened recurved spines, like those of *O. dillenii* but usually shorter, and a thick brush of stout bristles or spicules of a brown colour, those in the upper part of the areole being sometimes fully half an inch long. On the basal joints the areoles are frequently so near together that the joint is almost hidden by the spines and spicules, and it is sometimes difficult to say where the spines end and the spicules begin, there being a complete transition from one to the other (Plate IX.).

Joints of this type were brought to the Lands Office at Roma some years ago, and it was probably from this specimen that a plant in the Brisbane Botanic Gardens was grown for some years. A similar plant is growing near Dulacca, for information about which I am indebted to Mr. N. Culliford. Mr. E. R. Caldwell sent me a specimen from Taroom and Mr. R. Range sent a specimen from Warra to the Prickly-pear Lands Commission, who kindly presented it to me. Another specimen from Gogango was brought by Mr. W. Munns to the Westwood Prickly-pear Experiment Station. Mr. Munns stated that he had found the specimen at Gogango growing from a plant of pest pear (*O. bentonii*), and the specimen sent by Mr. Range consisted of two joints growing from the top of a normal joint of *O. bentonii*, proving conclusively that it was a bud-variation of that species. The sporadic occurrence of this plant in regions where the pest pear is common is thus satisfactorily explained.

There can be little doubt that if this plant was found in America, and its origin were unknown, it would be called *O. dillenii*, just as it was formerly in Australia. *O. dillenii* is a variable species, a plant from

Florida and another from Central America grown side by side at Sherwood remaining decidedly different. Neither of them has the profusion of spines and bristles possessed by most of the areoles of the mutation in question, but some of the most spiny areoles of *O. dillenii* could be matched among the less spiny areoles of the mutation.

The evidence suggests that *O. bentonii* is possibly a spineless mutation of *O. dillenii,* and that these bud-sports are reversions to the original form. The distribution of *O. bentonii* in America is said by Dr. D. Griffiths to extend from the mouth of the Brazos River in Texas to eastern Florida, but he adds:—"Always in cultivation in the eastern portion of this range and native in South-western Louisiana and Texas." Britton and Rose give the distribution of *O. dillenii* as:—"Coasts of South Carolina, Florida, Bermuda, the West Indies, east coast of Mexico, and northern South America; extending inland in Cuba." From these records it would appear that *O. dillenii* occurs all round the coasts of the Gulf of Mexico and the Caribbean Sea, except for an area from Texas to northern Florida, where *O. bentonii* occurs. One is tempted to suggest that in this region a spineless mutation known as *O. bentonii* has replaced the typical *O. dillenii.*

Dr. J. K. Small, writing of the prickly-pears of Florida, says of *O. dillenii*:—"This species is the common and typically maritime prickly-pear of our range, and also the most vigorous of the several different kinds. It is apparently the longest-lived and the healthiest of them all, seemingly wholly free from disease and also from insect pests. It grows either in perpetual shade or in exposed sunny localities and will stand almost any amount of ill-treatment and frequent transplanting for ornamental purposes with impunity.

"Although typically maritime and sometimes growing even in mangrove swamps or in low situations where the plants are partly submerged during high tide, it may be found equally vigorous on the high quiescent sand-dunes along the eastern coast of the Florida peninsula."

Most of these remarks would apply exactly to *O. bentonii* in Australia, except that it thrives even more inland than it does on the coast.

Another very interesting plant, which I have no doubt is a mutation from the common pest pear, was discovered by Mr. T. A. Cole, junr., in the bush near Chinchilla. I inspected it in his company and brought back joints which have continued to produce further joints of the same form. These joints are much more elongated than those of normal plants of *O. bentonii,* being ensiform instead of obovate. Every joint on the plant, which was a large one, had exactly the same form, as shown in the accompanying illustration (Plate X., figs. 1 and 2). The plant is growing in an area of dense pear amongst which no other plants with similar joints were noted.

The interest of this specimen is that its joints approach in form to those of *O. linguiformis* Griff. Britton and Rose state of this supposed species:—"This plant is rather common in cultivation in the South-west and is now found in most cactus collections. According to Dr. Griffiths, it is occasionally found wild near San Antonio, Texas. We have seen somewhat similar plants, from Brownsville, Texas, probably referable to one of the races of *Opuntia lindheimeri*. On account of the shape of the joints, this species is commonly called cow's tongue or *lengua de vaca.*"

It would thus appear that a tongue-shaped or sword-shaped mutation sometimes occurs in *O. lindheimeri* and that a quite similar mutation may occur in *O. bentonii*. Though the form of the joints is so different, the areoles, spines, and spicules are unchanged and thus give a clue to the origin of the new form.

An interesting plant found by Mr. A. N. Burns on the summit of Mt. Sebastopol, Westwood, is undoubtedly a mutation of *O. stricta,* amongst normal plants of which species it is growing. Joints transplanted to the grounds of the experiment stations at Westwood and Sherwood have continued to produce joints of the abnormal form. The abnormality consists in the fact that the joints are so narrow as to be almost cylindrical. Full-grown joints are about 6 inches long and only 1½ to 2 inches broad, whilst in normal plants of *O. stricta* they are from 2½ to 3 inches broad. In other respects this plant is normal. The form of its joints gives this mutation a superficial resemblance to the slender-jointed *Opuntias* placed in the sections *Curassavicæ* and *Aurantiacæ* by Britton and Rose.

The mutations referred to above have all proved to be viable, but there is a form of variation not infrequently met with which is apparently a non-viable abnormality. In this abnormality the joints are extremely short and crowded together and form a dense bunch sometimes resembling the head of a cauliflower, but at other times not so crowded. A bunch of joints of this nature growing on a normal plant is a fairly common phenomenon in the pear country and some bushmen refer to it as mistletoe. I have noticed abnormalities of this type on *O. bentonii, O. stricta, O. tomentosa,* and *O. elatior*.

The commonest of all abnormalities, both in *O. bentonii* and *O. stricta,* is one in which the fruits are all sterile. This variety was described in the case of *O. bentonii* by Dr. Jean White in the first of her Annual Reports of the work of the Prickly-pear Experimental Station, Dulacca. She found it was so common that she referred to it merely as "abnormal pear." These sterile plants of *O. bentonii* do not appear to differ in the form of their joints from normal plants. In the case of *O. stricta,* however, the sterile plants can be readily distinguished, since the spines on the joints are short and dull-grey in colour instead of yellow. The plants also grow taller than normal ones and the joints are somewhat lighter in colour, so that the sterile plants can be distinguished readily even if no sterile fruits are present on them.

IV.—HYBRIDS.

The flowers of the various species of *Opuntia* are so much alike that it might be anticipated that hybridisation would occur commonly between them in localities where they grow mingled together. In the Rockhampton district of Queensland the two principal pest pears grow mingled together over a very large area, and two other species are quite common, yet in the fifteen months in which I lived in that district I only once found a plant which I could not at once assign to one of the known species. Since then three other plants, probably of hybrid origin, have been shown me in the district.

Of these four supposed hybrids, two are apparently hybrids between *O. bentonii* and *O. stricta,* though it is possible that they are really mutations of one or other of these species. Both these plants were found at Westwood, one by myself, the other by Mr. A. N. Burns. The former has joints like those of *O. bentonii* in size, shape, and thickness, but with more spines than are normally found in that species. These spines are long and slender and closely resemble those typical of *O. stricta.* The fruits are sub-spherical as in the latter species.

The second supposed hybrid has joints larger than usual in *O. stricta,* 7 inches long and 4 inches broad, but otherwise agreeing in form with those of that species. The spines are exceptionally long, sometimes measuring over 2 inches, whereas in *O. stricta* they are usually from 1 to 1½ inches long. The fruits resemble those of *O. bentonii,* being markedly pear-shaped.

That the two other plants referred to above are actually hybrids there can be no reasonable doubt. One pointed out to me by Mr. T. Birkbeck at Glenmore is a single plant growing amongst plants of *O. stricta* and the Joconoxtle, and is intermediate between these very different species. The plant is low-growing like *O. stricta* and it joints have the size and the elliptic form characteristic of that species. In colour, however, they are bluish with a purplish patch round the areoles as in the Joconoxtle. The spines are white like those of the latter species and about the same length, shorter than those of *O. stricta.* The fruits have the form and colouring of those of the Joconoxtle but are much reduced in size.

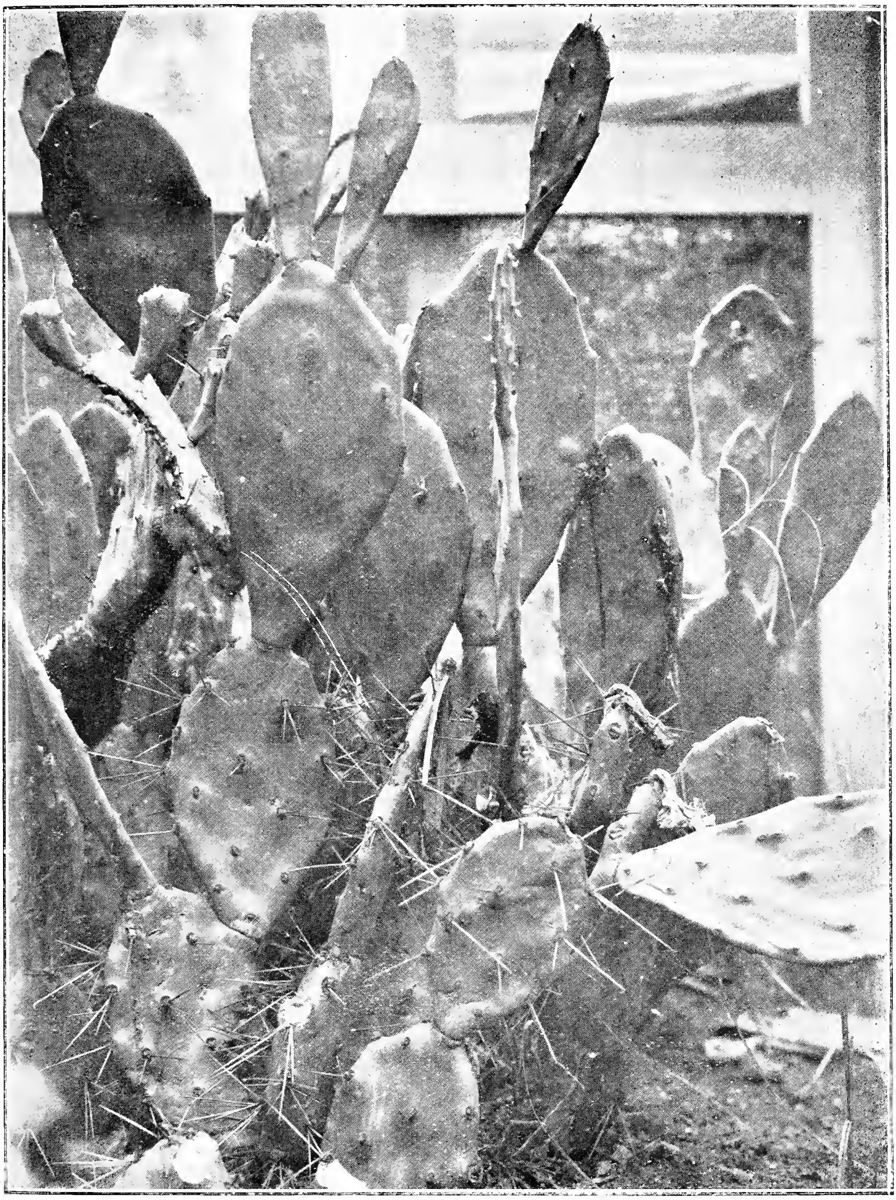
The following characters of *O. stricta* are dominant:—Low-growth (the Joconoxtle is a "tree-pear"), size of joints, form of joints, and size of fruit. The following characters of the Joconoxtle are dominant:—Colour of joint, form of spines, colour of spines, form of fruit, and colour of fruit.

The other undoubted hybrid was found by Mr. A. N. Burns at Gogango and is certainly the result of a cross between *O. stricta* and *O. tomentosa,* which are there growing intermingled. The plant is tall like the tree-pear (*O. tomentosa*) and the joints have the shape of those of that species, but entirely lack the characteristic tomentum. They are rather a bright green in colour, lighter than those of *O. tomentosa* and not so bluish as those of *O. stricta.* The spines are numerous and long, somewhat flattened and recurved, mainly white as in *O. tomentosa,* but somewhat banded with yellow, the colour of those of *O. stricta.* They are as plentiful as in *O. stricta* but longer than is usual in either parent. The flowers are pale orange-yellow, just intermediate in colour between the orange flowers of *O. tomentosa* and the yellow ones of *O. stricta.* The fruits appear to be intermediate between those of the two parents in every respect—shape, size, and number of areoles.

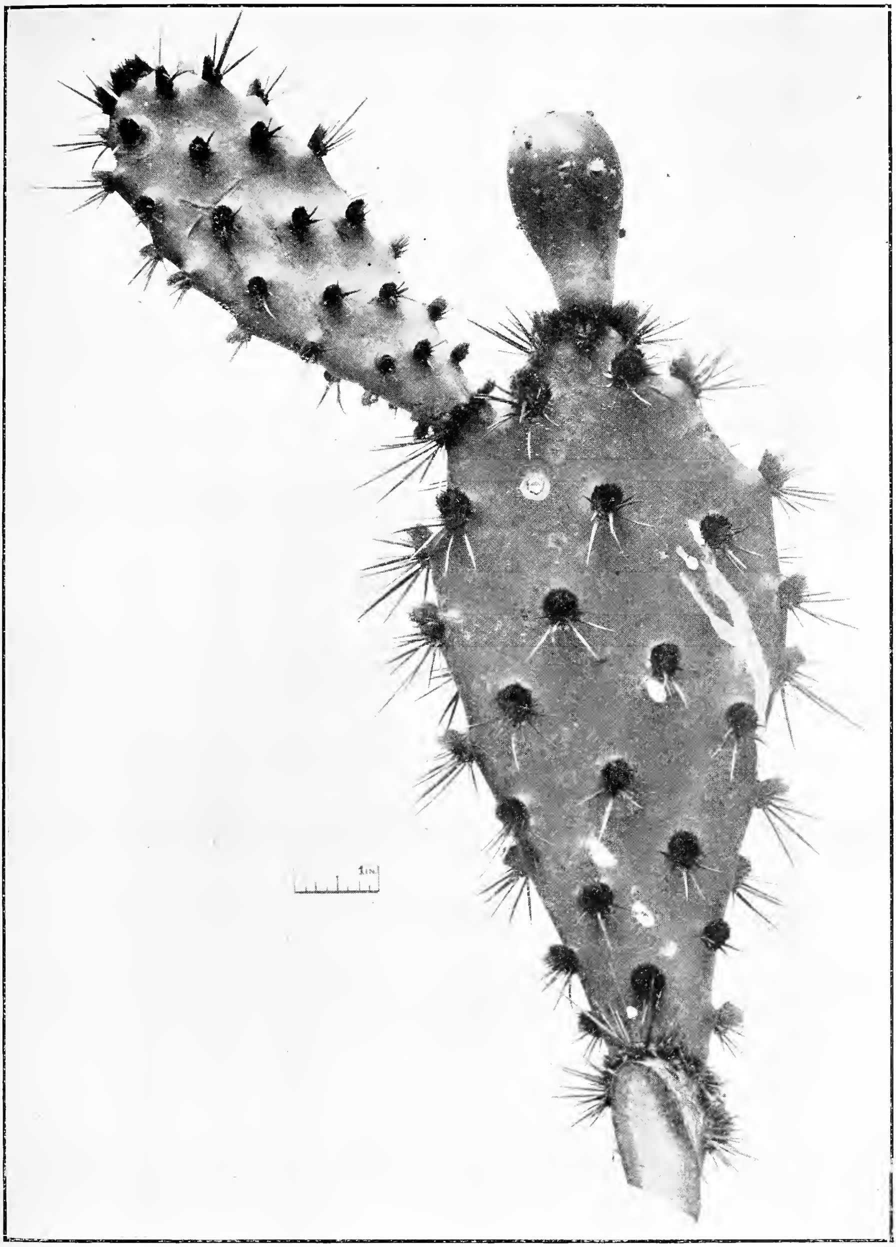
The following character of *O. stricta* is dominant:—Smooth cuticle. The following characters of *O. tomentosa* are dominant:—Tall growth and form of joints. In all other features the plant is either more or less intermediate between the parents, or presents characters different from those of either.

It is a curious fact that whilst the former hybrid agrees in every character with one or other of the parents, the latter is more or less intermediate between the parents in the majority of its characters.

[NOTE.—In the absence of the author in England this paper was communicated by Mr. C. T. White (Government Botanist, Brisbane), who suggested that a plate illustrating the very peculiar spiny variation of the Common Pest Pear (*Opuntia bentonii* Griff.) described by the author should be included. The approval of the Council was granted and an illustration (Plate IX.) is published herewith.—ED.]



SPINY PEST PEAR.
Showing spineless growth of upper joints due to shade.
[*Photo. by H. Hacker.*



SPINY BUD VARIATION OF *Opuntia Bentonii*.

Face page 54.]

Fig. 1.—Abnormal plant of Pest Pear, with ensiform joints, growing at Chinchilla, Q.

[*Photo. by W. B. Alexander.*

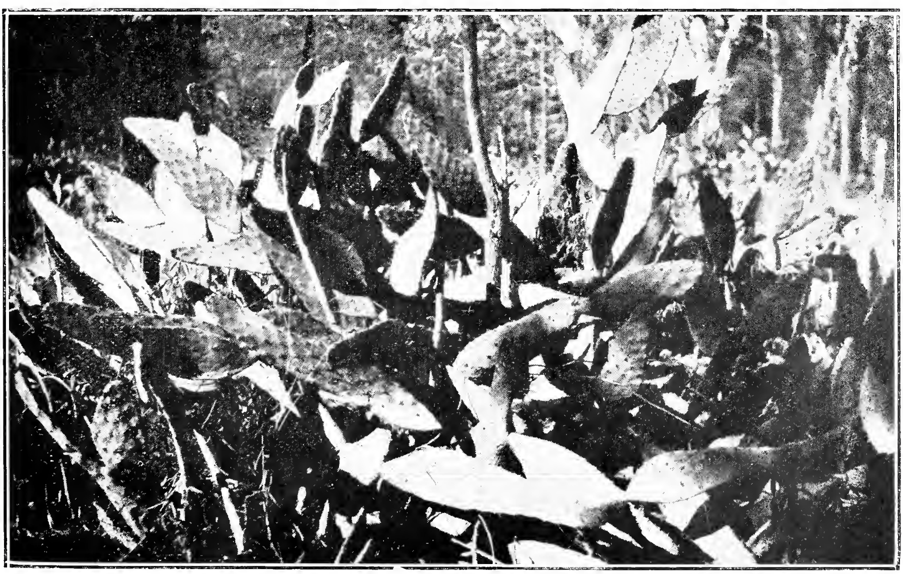


Fig 2.—Another view of the same plant (shown above).

[*Photo. by W. B. Alexander.*

[*Face page* 54]

The Apparent Twist in the Cotton Fibre an Optical Illusion.

By Thos. L. Bancroft, M.B.

(*Read before the Royal Society of Queensland*, 31*st May*, 1926.)

Some years ago, whilst microscopically examining cotton to ascertain whether there was really any difference between annual and ratoon cotton, I became interested to find out how the cotton fibre twisted without engaging other fibres.

In the case of the awn of the spear-grass seed, which is twisted on its axis, it engages other awns in doing so and makes a tangled mass.

Cotton does not tangle; every fibre is free from its end up to the seed. I searched for an explanation, but most writers merely stated that the fibre is twisted.

Sir George Watt, in his book, "The Wild and Cultivated Cotton Plants of the World," says:—

> "Cotton may be defined as a unicellular hair formed from the cuticle of the seed. If taken from a seed found within a pod that had not opened, the unicellular cotton tube is flattened lengthwise on itself, but if from a pod opened naturally in the process of ripening the cellular chamber may be observed to have become twisted on its own axis.
>
> "It would seem probable, however, as pointed out by Monie, that spiral twisting normally commences at the top and works towards the base of the cell."

I made miscroscopical preparations of cotton, principally mounted in canada balsam, and upon examination with very high powers I could make out that almost all of the apparent twists were not twists but the edges of the flattened tube in close position.

I tried to induce the Microscopical Society of Victoria to investigate the matter, and supplied material. I have recently had a communication from the Honorary Secretary, in which he says:—

> "The question requires lengthy and careful investigation by experts, which our members could not undertake. Some of our members, who examined the samples which you kindly sent down, came to the conclusion that the fibre is twisted."

I wish now to record the discovery, and let others confirm or refute what I have stated.

The cotton fibre in the green pod is a cylindrical tube filled with a watery protoplasm. When the pod dries the water evaporates from the cotton tubes, which collapse; they are then in the form of ribbons (Fig. 1). Under the best conditions of plant growth the ribbons become folded upon themselves (Fig. 2). This is the condition cotton spinners appreciate so much, a sample of cotton showing many regularly "twisted" fibres being more valuable than one with a few only.

Fig. 1

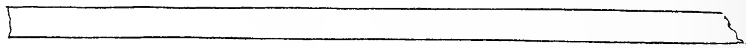


Fig. 2

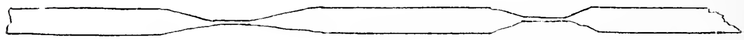


Fig. 3

Immature and otherwise defective fibres remain as ribbons.

Figure 3 represents the appearance of a mature, well-developed cotton fibre under the microscope.

An easy way to demonstrate that there are no twists is the following:—A few strands of cotton are pulled out straight and mounted on a slide with liquor potassae and a cover glass, and ten minutes at least is allowed for the action of the alkali. The fibres become softened and filled out with fluid, thus causing the disappearance of any folding or "twisting." A magnification of 50 diameters is sufficient.

A New Species of Pandanus from North-west Queensland.

By Count Prof. U. Martelli (Florence, Italy).

(Plate XI.)

(Communicated by C. T. White.)

(*Read before the Royal Society of Queensland*, 31*st May*, 1926.)

Pandanus (*Hombronia*) *de Lestangii* Martelli sp. nov.

Folia coriacea, circiter 180 cent. longa, e basi (7-8 cent. lata) usque ad apicem longiuscule subulatum sensim attenuata, in tertia inferiori parte plicato-canaliculata, ibique, in pagina inferiori, transverse minuteque venuloso-subtessellata, in pagina superiori laevia, caeterum utrinque longitudinaliter creberrime minutissime venulosa; plicis lateralibus inermibus, marginibus spinoso-dentatis, dentibus marginalibus partis basilaris, longiusculis, subulatis, erecto-patentibus, partis superioris brevibus, adproximatis; costa media filiformis, prominula acutaque, basin et apicem versus inermis, caeterum dentibus tenuibus vel minutis, subulatis, irregulariter remotis munita. Syncarpium solitarium, oblongum trigonum, 10-13 cent. diam. Drupae numerosissimae, solitariae, vel 2-3, rare 4-5 in phalangi uniseriatae, connatae, oblongo-cuneatae, sensim attenuatae, basi acutae, penta-exagonae, interdum compressae, 3½ cent. longae, 9-12 mill. crassae, apice rotundato-mammillari vel subrotundato brevissime papillato et si in phalangi connatae, bipluriloculares et loculis monoseriatis transverse dispositis, rotundatis, pentagonis a sulco subsuperficiali separatis. Stigma ad apicem papillae parvum, vel 2 rare 3, rarissime 5, planum vel subplanum, subhyppocrepiformis. Endocarpium osseum in parte mediana drupae situm, acute cuneiforme, superne truncatum, 1 cent. spissum et si pluriloculare superne subconvexum; mesocarpum superum 1-2 cavernis elongatis, amplis, spongioso-medullosis, inferum fibrosum.

Habitat: Australia; growing under palms along perennial streams about 200 miles south-west of Burketown (Burke District), North-west Western Queensland (Albert de Lestang).

Observation: The nuts are the favourite food of two species of turtle which abound in the streams along which this *Pandanus* grows (A. de Lestang).

This new species of *Pandanus,* according to the disposition of its drupes, may be ascribed to the Section *Hombronia.* It is much to be regretted that its male flowers are as yet unknown, because a knowledge of them would be of great use towards a surer determination of its divisional generic position. If this species really belongs to the

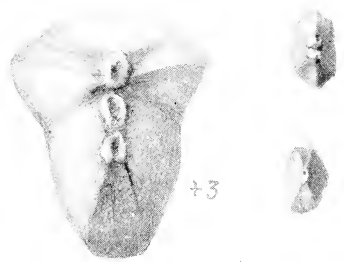
Hombronia, it will be the first one collected on the Australian continent, and the fact would be an important circumstance for the geographical distribution of the section.

At present, in a very few species of *Pandanus* only do we assuredly know both sexes, so that in many cases even a monographer must be perplexed about the right determination of a male sample. If the knowledge of both sexes in various species of *Pandanus* is desirable for a monographer, I consider it much more important under the aspect of a generic study, in order to establish a natural arrangement for the subdivisions of the genus in consequence, to be able to know the relations between the different sections, their geographical distribution, and perhaps also for giving a direction for a generic study.

For a long time I have felt convinced that the actual subdivision of the Genus *Pandanus* is in certain cases incomplete, imperfect, not at all clear, and not suitable to a homogenous systematic idea. Much more attention has been paid to the disposition of the drupes, to their association, to the position of the style as of the stigma, but not equally to the disposition and grouping of male flowers. I have observed that some species, whose male flowers show such a different aspect, have been ascribed to the same section, so that I cannot conceive how such evident diversity of conformation of male flowers, already noted by botanists, has not attracted the attention of the monographer. Perhaps the scarceness of male specimens surely determined was the cause of that carelessness? If the conformation of the drupes has been considered by itself as a sufficient base for the generic subdivision, it seems to me that the male flowers' conformation must have the same importance also. In conclusion, my opinion that male flowers, when differently conformed, must be ascribed to different sections, and that such conformation must correspond to a type of drupes (Sectio) co-ordinate to that of male flowers.

From what I have exposed above, the desirability of knowing both the sexes at least in most species of *Pandanus* is clear. Towards this I suggest to all botanists to take great care in collecting samples of both sexes of each species. By this means they may be sure, in the interests of science, of contributing largely to a better knowldge of this family—a family that is yet wanting of more researches and illustrations.

Pandanus deLestangii.
Left—Four drupes. Right—Two drupes in longitudinal section.



Pandanus deLestangii Martelli.
Drupes viewed from above, natural size and × 3.

[*Face page* 58.]

Effects on Mosquito Larvae of a Queensland *Nitella*.

By E. W. I. BUHÔT, Inspector, Department of Public Health, Brisbane.

(*Read before the Royal Society of Queensland, 31st May, 1926.*)

Ever since Caballero[1] in 1919 first published his experiments with *Chara fœtida* on the larvæ of mosquitoes of the genera *Stegomya, Culex,* and *Anopheles,* considerable interest has been taken on the question of the effect of various species of Characeæ in different parts of the world on mosquito larvæ.

My attention was first drawn to the subject by a résumé of Caballero's work in the "Bulletin des Sciences Pharmocologique."[2]

Since Caballero's researches a number of contributions to the subject have been made by various authors—some supporting and others rejecting his theory. The latest contribution on the negative side has been made by Macgregor,[3] who conducted experiments with both living plants and watery and alcoholic extracts. His views on the matter are summarised in the following paragraph:—

> "Taking the evidence as a whole it is difficult to conclude whether *Chara* is entirely devoid of the larvicidal action imputed to it, or whether under certain conditions, and in certain localities, some species have the power of inhibiting mosquito development, but I am convinced personally by my own experiments and observations that even some of the reputedly toxic species are often devoid of any toxicity whatever."

At a meeting of the Linnean Society of London on the 19th June, 1924, reported in the "Journal of Botany,"[4] Mr. T. B. Blow gave an account of his work in Madagascar in which he spent seven weeks making a large collection of Charophytes and studying the various species in their relationship to mosquito larvæ. The species that seemed to keep the water quite free from mosquito larvæ were as follows:—*Chara zeylanica, C. gymnopitys, Nitella Roxburghii,* and some other species of *Nitella,* probably new.

In January, 1925, I obtained specimens of a Charophyte which were submitted (through the Government Botanist, Mr. C. T. White) to Mr. Jas. Groves, the well-known authority on the group.

Mr. Groves replied:—

> "I am sorry not to be able to speak with greater certainty about the plant as all the mature pieces sent belonged to the male plant, which is not nearly so satisfactory for identification as the female of a dioecious species. However, I feel little doubt that it is a new species, and I have provisionally called it *Nitella phauloteles* on account of the very small end cells of the dactyle."

The experiments with the *Nitella* were commenced on the afternoon of the 20th January, 1925. I collected and planted the *Nitella* in a glass aquarium in ordinary black soil and three parts filled the aquarium with rain water—13 gallons. The plant was well under the surface of the water, as I noticed that it grew on the bottom of the creek well under the running water, or, where noticed in stagnant water, the plant never rose to the surface. The fact is worthy of notice that the plant slowly dies if the water is not kept well over it. It was also noticed that the plant never attains to the surface of the water in any place where it has been observed.

Daily observations of the plant were made as to growth, &c., also attention was paid to the depth of water in the aquarium, this being always at about the same height, never allowing the plant to grow too near the surface of the water.

On the morning of the 27th January a green scum and also a thin film resembling oil were noticed on the surface of the water. Upon examination, the green scum proved to be due to bacterial growth, and the thin film being the peculiar oil-like substance given off by the plant, which, in my opinion, has the deterrent effect on the female mosquito, preventing her from laying her eggs upon the surface of any creek, pool, tank, or receptacle where this plant should be growing.

On Saturday morning, 31st January, I collected some mosquito larvæ, *Culex fatigans,* and placed them in the tank where the Nitella was growing. On Monday morning, 2nd February, the larvæ were still alive. On the succeeding day they were still alive and remained so for two more days, when they were noticed to be very sick, and on the 6th February the larvæ were found to be dead.

I then placed two other aquaria alongside the one which contained the *Nitella* and put the same amount of water in them with soil and other aquatic plants. Mosquitoes bred in these aquaria, but not in the one containing the *Nitella,* thus to some extent proving that the water in this particular aquarium was repellent to the female mosquito. To prove this further, I procured some female mosquitoes which I had bred out and which had been fecundated and allowed them to feed upon my blood; after which I transferred them under a mosquito net which was screening the *Nitella* aquarium and allowed them full access to the surface of the water, watching them whenever opportunity offered. A month elapsed, and during that time I continually found dead female mosquitoes on the surface of the water, and on careful examination of the surface I could not discover any eggs nor did any mosquito larvæ appear in the aquarium up to the 1st October, 1925. Some mosquitoes were also found on the floor; these had apparently fallen off the net where they had been resting.

I may also mention that in the other aquaria where mosquitoes were caged they laid their eggs upon the surface of the water in great numbers. This appears to be another link in the chain of evidence that at least some species of Characeæ have repellent properties to the mosquito.

Various species of mosquitoes were tried, including *Stegomyia fasciata* (*Aedes egypti*), *Culex fatigans* (*quinquefasciatus*), and *Anopheles nyssorhynchus*. All gave the same favourable and pleasing results, not laying their eggs upon the surface of the water in the aquarium where the *Nitella* grew.

Then came the necessity of proving that the toxic effect given off by this plant was not poisonous to man and animal life.

The following methods were adopted and their results carefully noted:—

On the 11th June, 1925, I obtained seven live rats which I placed in a cage and fed them on dry food; the only drinking water given them daily for a period of one month was the water taken from the aquarium containing the Characeous plant; the rats lived and were always well and in a healthy condition. No difference was noticed in the health of the rats after another month under the same conditions. The rats were then destroyed and post-mortem examination showed all internal organs to be in a healthy state.

To further test the water, I introduced fish, and they have lived and thrived for some months in the aquarium containing the *Nitella;* also slugs have been placed in the same water and are still alive.

To further demonstrate the harmlessness of water from any creek, tank, or pond in which *Nitella* grows, I have for the past two months been drinking two glasses daily of the water taken from the aquarium and have not noticed any ill effects therefrom.

The plant grows prolifically, reproduces freely, and is easily transplanted, also fresh growths may flourish until the whole bed of the creek becomes closely covered with the growth of the plant.

For ornamental ponds it can readily be used and should prove a boon to the users. From all my experiments I cannot speak too highly of the *Nitella phauloteles,* and I feel sure when my further experiments have been completed through this summer the plant will come into general use in the large lagoons and swamps which abound in the Greater Brisbane area and which now afford a breeding-ground for mosquitoes.

Acknowledgments.—I have to express my thanks to the Public Health Commissioner (Dr. Moore) for facilities given for carrying out these experiments, and to Mr. C. T. White, Government Botanist (Queensland), for the material assistance.

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The Development of the Corrugated Stems of Some Eastern Australian Trees.

By W. D. Francis, Assistant Government Botanist.

Plates XII.-XIV. Text-figures 1-4.

(*Read before the Royal Society of Queensland, 28th June, 1926.*)

Contents.

I. Introductory Remarks.

Several Eastern Australian trees are characterised by flanged stems. Species possessing this feature are enumerated by the writer in a paper published in these Proceedings[1]. Another peculiarity of several species of trees in the same region is the corrugated or longitudinally wrinkled surface of the sapwood. The species exhibiting this modification are recorded in the same paper ([1], p. 215). The observation and recording of the species possessing these somewhat distinctive features were the result of field work. In this paper it is proposed to outline the results obtained by applying laboratory methods of investigation to an example of a species with a flanged stem and to a number of examples of species with corrugated or wrinkled woody cylinders.

II.—Methods.

Transverse sections of complete stems or of suitable parts of stems were ground down with sandpaper to a smooth surface. The gross structure could then be observed. Selected parts from these large sections were then taken and prepared for microscopic examination. For this purpose the small pieces of wood were alternately boiled and cooled in water until the air was removed from them. They were then immersed in strong hydrofluoric acid for periods varying from two weeks to four months in order to remove the silica and other mineral constituents. When sufficiently softened, sections were cut with a sliding microtome. The sections were stained with Heidenhain's iron hæmatoxylin and safranin, dehydrated, cleared, and mounted.

III.—The Flanged Stem of *Villaresia* (*Chariessa*) *Moorei* F. v. M.

This species is sometimes commonly known as Churnwood or Soap-box. It is found in the rain forests from Shoalhaven (35 deg. S.) in New South Wales to Gympie (26 deg. S.) in Queensland. In the field it is a characteristic tree which can be identified by its flanged stem, thick, furrowed, pale-gray, cork-like bark, and its pale wood with large rays. It is one of the largest rain-forest species, and is frequently found growing on hillsides in Queensland. Mr. C. T. White, Government Botanist, informs the writer that it is one of the most plentiful trees on the Bunya Mountains. The writer has observed it in the rain forests of Kin Kin, Traveston, Tambourine Mountain, and the Macpherson Range near Killarney. The accompanying field photograph and the drawing representing the stem in cross section show the peculiar form of the tree. The species under investigation might be considered to possess a buttressed stem, but, somewhat arbitrarily, perhaps, it was not included with the buttressed trees listed by the writer[2] because the flanged shape is not restricted to the basal portion of the stem, but is frequently continued upwards in a diminishing degree to a great distance, in some cases almost reaching the lowermost branches.

As the woody portion of the stems of dicotyledonous trees (which include all the species discussed in this paper) increases in thickness by the addition of successive increments of wood at the external boundary, a cross section of a stem usually shows the successive changes of shape, if any, which the stem has undergone at the particular plane in which it is sectioned. The degree of differentiation of the successive increments of wood is determined chiefly by their differences in structure and colour. The transverse section of the stem represented by text-figure 1 was cut from a tree in a horizontal plane situated 2·4 metres (8 feet) from the ground. It shows that the young tree retained an approximately cylindrical stem at this height until it attained a stem diameter of about 17·5 cm. (7 in.). Subsequently the stem developed irregularly and formed three large angles and one small one, alternating with four grooves or intrusions. The stem when measured might be described as having a maximum diameter, extending to the outer edges of the angles or extrusions, of 60 cm. (24 in.) and a minimum diameter, bounding the intrusions or grooves, of 31·5 cm. (12·5 in.). By subtracting the diameter of the stem when it was approximately cylindrical from the foregoing maximum and minimum diameters we obtain a measure of the extent of the irregular development of the stem. In this way it is found that during the course of its irregular development the stem added 42·5 cm. (17 in.) to its diameter in the direction of its extrusions and only 14 cm. (5·5 in.) towards the grooves or intrusions. Hence, while irregular expansion was proceeding, growth in thickness towards the extrusions ensued at three times the rate of growth towards the grooves.

The surface of the sapwood is comparatively smooth and even where it bounds the extrusions, but in the grooves it is seen to be thrown into folds which can be traced inwards for some distance. These folds, however, clearly originate some distance outwards from the zone indicating the inception of irregular development.

Text-figure 1.—Transverse section of stem of *Villaresia Moorei*, $\frac{1}{4}$ natural size. Section cut 8 feet from ground. The dotted lines represent some of the more conspicuous rings of growth. The shaded areas indicate patches of parenchyma. The bark is shown by the heavier shading on the exterior. The section was taken from a tree growing on the Bunya Mountains.

The direction of the rays is a remarkable feature of the section. Two very large rays originate towards the pith, but are not continued very far outwards. They arise by the fusion of a number of smaller rays and do not produce any prominent inward flexion of the periodic zones

Lower portion of stem of *Villaresia* (*Chariessa*) *Moorei*. The tree represented grew on a hillside in rain forest at Kin Kin, about 26.2 deg. S. (eastward from Gympie). The angular form of the stem is evident. The continuity of the projecting angles of the stem with the principal surface roots is shown.

[*Photo. by W.D.F.*

[*Face page* 64.]

of tissue, as is shown in the species dealt with in the latter part of this paper. In the earlier stages of growth, while the stem retained an approximately cylindrical shape, the rays diverge from one another in their course outwards, but subsequently to the inception of irregular growth their direction in portions is changed. The divergent direction of the rays is maintained in the extruding sectors, but in the sectors bounded by the grooves their divergent disposition is gradually lost and eventually reversed, for they ultimately become convergent in their outward course.

Anatomical investigation shows that a peculiar structural feature of the wood in the form of patches of thin-walled, almost rectangular cells constituting parenchymatous tissue appears in the sectors bounded by the grooves. These patches of parenchyma appear subsequent to the inception of irregular growth and in areas where the rays are convergent. The vessels and wood fibres present in the normal wood disappear or are only scantily represented in the parenchymatous patches (compare photomicrographs 1 and 2, Plate XIII.). The rays as they approach the patches of parenchyma become broader and are more or less indistinct where they enter them.

The location of the parenchymatous areas in parts of the stem characterised by rays which are convergent in their outward course suggests that these areas might have arisen through lateral pressure on the cambium or generative tissue. The effects of lateral pressure in the neighbourhood of the parenchymatous patches are indicated by the presence of folds in the zones of growth of the outer portion of the sectors bounded by the grooves of the stem. The outwardly convergent rays and the folded zones of growth indicate that the cambium which produced them suffered contraction. On the other hand the divergent rays throughout the extruding sectors of the stem indicate that the cambium which produced them underwent expansion. As the extruding parts of the stem are continuous with and most prominent in the region of the principal surface roots of the tree, the irregular growth of the stem is associated with the development of these surface roots.

IV.—The Corrugated Woody Cylinders of Several Species.

(a) *General.*

When the bark is removed from the stems of some species of trees, the surface of the sapwood is seen to be wrinkled or corrugated in a longitudinal direction (see text-figures 3 and 4). The trees which exhibit this peculiarity are sometimes known as "Corduroys" or "Washing-board Trees" on account of the resemblance of the sapwood surface to corduroy cloth or washing-boards. In the case of large examples of the Washing-board Tree of Eungella Range, *Cryptocarya corrugata,* the depressions of the sapwood surface are indicated on the outer surface of the bark, but in the majority of the other species the corrugations are not conspicuously represented on the outer surface of the bark. A corrugated sapwood surface was observed by the writer in a number of species of trees belonging to the Natural Order Sapindaceæ and one species of *Cryptocarya,* and a list of these species was published ([1], p. 215). Subsequent observation showed that, in addition to the species of Sapindaceæ and *Cryptocarya,* the peculiarity is exhibited by several species of *Canthium* (Rubiaceæ) and *Casuarina* (Casuarinaceæ).

Following are the species of Eastern Australian trees in which the corrugated sapwood surface has been observed by the writer to be prominent:—

Casuarinaceæ—

Casuarina inophloia F. v. M. and Bail., Thready-bark Oak.
Casuarina torulosa Ait., Forest Oak.
Casuarina suberosa Otto & Dietr., Black Oak.

Lauraceæ—

Cryptocarya corrugata White and Francis, Washing-board Tree.

Sapindaceæ—

Alectryon connatus Radlk. (Nephelium connatum F. v. M.).
Guioa semiglauca Radlk. (Cupania semiglauca F. v. M.).
Diploglottis Cunninghamii Hook f., Native Tamarind.
Sarcopteryx stipitata Radlk. (*Ratonia stipitata* Benth.), Corduroy.
Arytera Lautereriana Radlk. (*Nephelium Lautererianum* Bail.), Corduroy Tamarind.

Rubiaceæ—

Canthium latifolium F. v. M.
Canthium lucidum Hook & Arn.
Canthium coprosmoides F. v. M.
Canthium buxifolium Benth.

R. T. Baker[3] mentions grooves on the surface of the sapwood of *Cryptocarya glaucescens* R.Br., an Eastern Australian species, and states that they are associated with large, multiseriate rays in the wood. A corrugated sapwood surface is also described in an undetermined species of *Cryptocarya* in the mountains of Papua by C. E. Lane-Poole[4]. I. W. Bailey[5] refers to the strongly fluted stem of the American Blue Beech (*Carpinus caroliniana* Walt.) and states that the furrows in the stem correspond to bands of closely approximated compound rays. He describes aggregate rays in several genera of the Natural Order Cupuliferæ, among the lower dicotyledons, similar to structures to be subsequently described in this paper, and ascribes their origin to leaf traces. He states ([5], p. 232) :—"In the development of the large storage systems necessary to plants living in regions of markedly unequal seasonal temperature characteristic of later geological time, the origin of storage tissue about the entering leaf trace has proved a natural starting point for the formation of compound or aggregate rays." The inward flexion of the zones of growth where they are crossed by large rays is discussed by E. C. Jeffrey[6] in a number of species of plants, and is assigned to the retarding effect of the large rays on growth. Herbert Stone[7] figures a section of the wood of the European Hornbeam (*Carpinus Betulus* Linn.) showing the annual rings bending inwards where they are crossed by large aggregate rays, and he states that the indentations indicate deep, spindle-shaped grooves on the exterior of the trunk.

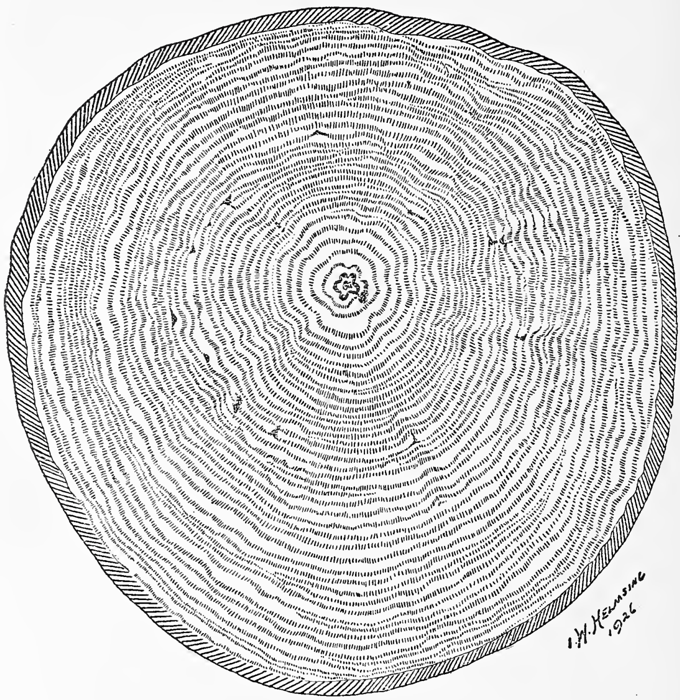
Gross and microscopical sections of the wood beneath the sapwood corrugations of *Casuarina inophloia, Cryptocarya corrugata, Sarcopteryx stipitata, Arytera Lautereriana,* and *Canthium latifolium* were made and examined. It was found that the corrugations were accompanied by modifications of or special structures in the underlying wood in each example of the several species examined. The stem of *Arytera Lautereriana* was sectioned at several stages of growth, and its modifications are described in more detail than those of the other species.

(B) *Arytera Lautereriana.*

This species is confined to Queensland and has been found in the rain-forests as far south as the Glasshouse Mountains (27 deg. S.) and as far north as the Eungella Range (21 deg. S.), westward of Mackay. It attains a stem diameter of about 40 cm. (16 in.) and a height of 27 metres (90 ft.). The young stems, when examined in cross sections, show the central 5-lobed pith corresponding to the $\frac{2}{5}$ phyllotaxis of the species. The young woody cylinder also exhibits five depressions in the surface of the sapwood corresponding to the five indentations of the pith (see inner portion of text-figure 2). In addition to the five depressions of the sapwood surface, the young woody cylinder in the region of the node possesses smaller depressions caused by the median and lateral leaf traces. The median trace passes outwards from the apex of a lobe of the pith, and each of the two lateral traces associated with it passes outwards from the side of the apex of each of the adjacent lobes of the pith. The depressions on the sapwood surface caused by the leaf traces disappear at a distance of 1·2 cm. ($\frac{1}{2}$ in.) above and below the centres of the traces.

Examination of a transverse section of a stem 9 cm. (3·5 in.) in diameter, represented in text-figure 2, shows that slight irregularities in the zones of growth make their appearance after the five indentations of the young stem have disappeared. These slight irregularities frequently become more prominent in outer portions of the stem and produce the slightly sinuous outline of the sapwood surface. In large stems the irregular zones of growth become very conspicuous and terminate in the strongly corrugated surface of the sapwood (see text-figures 3 and 4).

Upon microscopic examination of sections of young stems it is seen that the rays in the wood extending outwards from the projecting lobes of the pith diverge from one another in a fan-like manner, whilst the rays in the wood passing outwards from the indentations of the pith are almost parallel. It is, therefore, indicated that the wood outwards from the projections of the pith expands in a lateral as well as in a radial direction, whilst that outwards from the indentations of the pith undergoes little or no lateral extension. This unequal lateral development of sectors of the stem is shown by the preservation of the outlines of the pith indentations almost unaltered in the zones of growth of the young



Text-figure 2.—Transverse section of stem of young tree of *Arytera Lautereriana*, natural size, showing the 5-lobed pith, a number of small, dark patches (between the pith and the bark) and the sinuate surface of the sapwood.

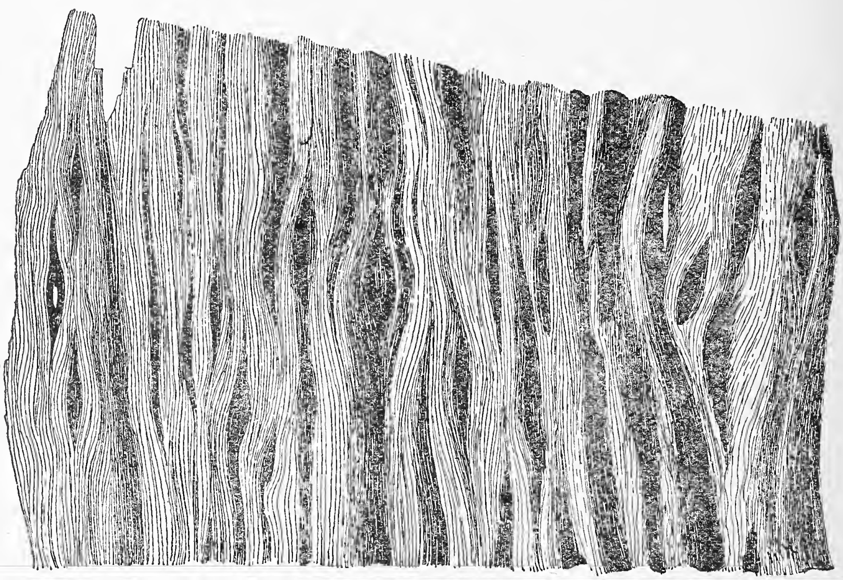
stems. Although the irregularities of growth associated with the pith indentations and the leaf traces are not prominent on the surface of the woody cylinder of one stem measuring 4 cm. (1·6 inch.) in diameter, the inflexions caused by some of the indentations of the pith are still noticeable on the surface of the sapwood of another stem measuring 22·5 cm. (9 in.) in diameter. The narrow band of tissue associated with the leaf traces consists of aggregated rays.

In several instances depressions on the sapwood surface of larger stems have been traced inwards in a radial direction to small, brown-coloured patches. Photomicrographs 5 and 6 show a portion of a section of the tissues in and surrounding one of these brown-coloured patches which was situated about 2 cm. (·8 in.) from the centre of the stem. The dark area shown in the lowermost part of photomicrograph 5 and towards the middle of photomicrograph 6 represents the small, brown-coloured patch. This dark area owes its appearance to a deposit in the cells of the wood. The deposit is a substance which gives the same colour reactions as tannin to reagents such as ferric salts (dark blue colouration) and potassium bichromate. The upper, dense part of the dark, tannin-bearing area is fairly sharply defined by a zone of growth in the wood. Subsequent zones of growth undergo inflexion towards a median line running from top to bottom of the photomicrographs. This median area is characterised by a small group of thick-walled, copiously pitted, parenchymatous cells (shown as a dark, irregular patch above the dark, tannin-bearing zone) and by the absence of vessels and the presence of cells with comparatively large lumina and thin walls. The thin walls indicate that the septate fibres, of which the wood of this species is chiefly composed, are only slightly lignified in this area.

The composition of the brown-coloured patches and the structure of the associated tissues as described and illustrated are suggestive of the effects of injury. On the young stems of this species there are frequently oval or elliptical scars possibly caused by the attacks of insects. The tissues beneath these scars show a deposit of the tannin-containing substance in the fibres of the injured area which consists of confused tissue containing many radially directed and oblique septate fibres.

A polished section showing the small, brown-coloured patches, to which some of the sapwood indentations were traced, was shown to Professor E. C. Jeffrey, who was then on a visit to Brisbane, and he remarked that the brown-coloured patches were "medullary patches" or "pith flecks." Herbert Stone ([7], p. 187) states that pith flecks are the result of injury to the cambium by minute insects, such as *Agromyza carbonaria,* which burrow under the bark. A similar explanation is adopted by S. J. Record[8] who states that pith flecks are composed of irregularly shaped, parenchymatous cells with thick walls copiously pitted with simple pits. These thick-walled cells are evidently similar to those described above by the writer as associated with the small, brown-coloured patches. It is, therefore, evident that some of the sapwood corrugations of *Arytera Lautereriana* are of pathological origin. The cambium of the trees is injured. As a result, concentric growth is arrested in the injured area and the cambium producing the subsequently formed wood loses the ability of forming vessels in radial areas extending outwards from the injured part. It will be shown subsequently that some of the sapwood corrugations are associated with radial bands of tissue from which vessels are excluded.

The wood beneath and in the vicinity of prominent indentations of the sapwood surface in mature trees measuring about 30 cm. (12 in.) in stem diameter, exhibits the structure shown in photomicrographs 3 and 4. The transverse view shows the inflexion of the zones of growth associated with two parallel, dark bands of aggregated rays which are disposed in a radial position in the stem. Vessels are absent from each of the aggregated rays and the rays constituting the aggregations are frequently several cells in breadth, showing that the normal, uniseriate rays of the wood have undergone fusion in many instances. The tissue between the two bands of collected rays consists of a few obliquely cut



Text-figures 3 and 4, natural size. 3 (upper): Transverse section of outer part of stem of large tree of *Arytera Lautereriana* with bark removed, showing the irregular outline of the surface of the sapwood and the irregular zones of growth. 4 (lower): Part of the stem of large tree of *Arytera Lautereriana* with bark removed, showing the corrugated surface of the sapwood.

vessels, a number of isolated, narrow, uniseriate rays, and many obliquely cut, septate fibres, which occupy the greater part of the space. The clearness of the section is marred to a certain extent by the abundance of the tannin-containing deposit present in the lumina of the fibres and in the cells of the rays. The tangential view shows a lens-shaped area almost surrounded by the two bands of approximated rays, which in turn are bounded on each side by tissue containing longitudinally cut vessels and uniseriate rays scattered throughout septate fibres. The lens-shaped area occupying the middle of the picture is characterised by several transversely cut vessels, scattered rays, and very numerous septate fibres cut in longitudinal, oblique, and transverse directions. Sections of the wood in the neighbourhood of some of the indentations show a less specialised development. In these cases there are two parallel bands of radially directed tissue from which vessels are absent. These bands of tissue possibly represent a stage in the development of the aggregate rays which have been described and are represented in photomicrographs 3 and 4.

The tissue situated between the two aggregate rays, which are associated with the sapwood indentations, is often of a less durable character than that of the normal wood. It is sometimes found in a decayed condition and detracts from the commercial value of the wood of the species.

(c) *Sarcopteryx stipitata.*

The anatomical features associated with the depressions in mature trees of *Sarcopteryx stipitata* are similar to those in *Arytera Lautereriana* in the later stages of growth. As in the latter species, the normal, scattered rays are mostly uniseriate or one cell in breadth, but in the two parallel bands of aggregate rays associated with the depressions large rays several cells in breadth are frequent.

(d) *Canthium latifolium.*

The corrugated sapwood surface is evident in trees of *Canthium latifolium* when they attain a stem diameter of 2·5 cm. (1 in.). The sections illustrated in photomicrographs 7 and 8 were prepared from a stem 4 cm. (1·6 in.) in diameter. They show that the anatomical features connected with the sapwood depressions are similar to those in mature trees of *Arytera Lautereriana.* The scattered rays of the wood are mostly one or two cells in breadth, but those approximated in the two parallel bands associated with the indentations are frequently much broader.

(e) *Cryptocarya corrugata.*

Sections of large stems of *Cryptocarya corrugata* also exhibit structural features in connection with sapwood indentations similar to those in *Arytera, Sarcopteryx,* and *Canthium.* In this species the scattered rays of the wood vary from one to three cells in breadth, whilst those approximated and partly fused in bands and related to the sapwood indentations are often considerably larger. The occurrence of two parallel bands of rays, which is remarked upon in the three preceding species, is not shown in the sections represented in photomicrographs 9 and 10. These sections were prepared from a piece of wood collected by the writer from a comparatively small tree about 22 cm. (9 in.) in stem diameter which also furnished the herbarium specimens constituting the type material of the species. The sapwood indentations were not so strongly developed in this instance as in larger trees of the species. In a large tree the indentations attained a length of 13 cm. (5·2 in.) and a depth of 5 mm. (·2 in.). In a specimen of the wood of the species supplied by the Queensland Forest Service, the occurrence of two parallel bands of aggregated rays in connection with inflexions of the zones of growth is frequent.

(F) *Casuarina inophloia.*

The transversely cut surface of the stem of *Casuarina inophloia* shows that the rays are comparatively narrow near the centre, but become gradually broader as they pass outwards. It also shows that the young stem was cylindrical until it attained about 8 mm. (·3 in.) in diameter, and that in subsequent growth the corrugated character of the sapwood gradually made its appearance. The indentations of the sapwood in mature trees attain a length of 3 cm. (1·2 in.) and are a prominent feature of the stem when the bark is removed. The structure of a large aggregate ray related to an indentation is shown in photomicrographs 11 and 12. The tissue composing the ray is much more compact than that of corresponding structures in the other species described in this paper. A few wood fibres are seen traversing the ray in oblique and transverse directions in the tangential view, and uniseriate rays are scattered throughout the wood on each side of the aggregate ray. The double or paired character of the structures in *Arytera, Sarcopteryx,* and *Canthium* is not evident in this instance.

V. Summary.

A transverse section of the stem of *Villaresia Moorei* indicates that the young tree retained an approximately cylindrical stem until it attained a stem diameter of about 17·5 cm. (7 in.). Subsequently the section of the stem assumed an angular contour and growth in thickness towards the extrusions proceeded at three times the rate of growth towards the grooves. The inception of irregular growth was succeeded by the convergence of the wood rays in their outward course in the sectors bounded by the grooves. In these sectors the convergence of the rays was frequently accompanied by an increase in the breadth of the rays, the occasional extinction of vessels and wood fibres, which were replaced by patches of parenchyma, and finally the appearance of folds or crenulations in the outer zones of growth. The convergent rays and the folded zones of growth are suggestive of lateral pressure, which might have caused the peculiar structure of the wood in the sectors

bounded by the grooves. The lateral pressure would result from the irregular growth, which, in its turn, is associated with the development of the principal surface roots.

Transverse sections of young stems of *Arytera Lautereriana* exhibit five indentations alternating with an equal number of rounded extrusions on the external surface of the woody cylinder. The configuration of these indentations and extrusions corresponds to the outline of the pith. Smaller indentations occur at the region of the node in relation to the median and lateral leaf traces. In some instances depressions on the surface of the sapwood of a stem measuring 9 cm. (3·5 in.) in diameter were traced inwards to small, brown-coloured patches, which upon sectioning were found to be areas in which the lumina of the cells of the wood are filled with a brown substance, which gave reactions similar to those of tannin on the application of solutions of ferric salts and potassium bichromate. These small, brown patches contain groups of thick-walled, copiously pitted parenchymatous cells in addition to the normal elements of the wood. They appear to be the result of injury, possibly by insects. The prominent indentations of mature trees are connected with pairs of large, aggregate rays terminating in the surface of the sapwood where the indentations occur. The sapwood indentations of *Sarcopteryx stipitata* and *Canthium latifolium* are associated with similar pairs of large, aggregate rays. Large, aggregate rays are also related to the corrugations of *Cryptocarya corrugata* and *Casuarina inophloia*. Aggregate rays in association with sapwood indentations occur in some of the higher dicotyledons as well as in some of the lower orders of that class, as indicated by their occurrence in the Natural Order Rubiaceæ. The indentations were found to be most prominent in large, mature trees of the various species examined.

Acknowledgments.—The writer is indebted to the Provisional Forestry Board of Queensland for some of the wood specimens which were utilised. The following officers of the Board obtained the specimens:—Mr. N. D. Allom and his staff, Mr. J. R. Dawson and his staff, and Mr. Chas. Watson. Mr. C. T. White, Government Botanist, kindly supplied wood specimens of *Sarcopteryx stipitata* which he had collected on the Macpherson Range. The Agricultural Chemist, Mr. J. C. Brünnich, kindly provided the hydrofluoric acid which was used in preparing the material for sectioning. Appreciative acknowledgement is also expressed to Mr. I. W. Helmsing, Artist of the Department of Agriculture and Stock, who drew the text-figures with which the paper is illustrated.

[Botanic Gardens, Brisbane.]

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EXPLANATION OF PHOTOMICROGRAPHS WITH NOTES ON THE ANATOMY OF THE WOODS.

PLATE XIII.

1. Transverse section of normal wood of *Villaresia Moorei*. Some of the vessels show portions of the scalariform perforations of their terminal walls as bands crossing the lumina. The rays are of two kinds, multiseriate and uniseriate, and constitute the darker bands passing from top to bottom of the picture. The wood parenchyma is shown as dark cells either single and scattered or in rows arranged transversely to the rays or partly surrounding the vessels. The remainder of the tissue consists of the fibrous elements, the tracheides, which have small lumina and thick walls and constitute the lighter portions of the picture. In longitudinal sections the perforations of the tracheides are seen to consist of bordered pits and the lateral walls of the vessels are provided with scalariform openings. According to A. Engler (Engler und Prantl, Die naturl. Pflanzenf, III., V., 235, 1896) the wood of Icacinaceæ (in which *Villaresia* is included by Engler) is characterised by tracheides with bordered pits and vessels with scalariform openings.

2. Transverse section of the wood of *Villaresia Moorei*, showing the transition from the normal wood to parenchymatous tissue in a part of the sector of the stem bounded by a deep groove. In the lower and right side of the picture the vessels, rays, wood parenchyma, and tracheides of the normal wood are seen. In the upper and left side the elements of the normal wood are replaced by large, more or less rectangular cells constituting parenchyma.

3. Transverse section of the wood of *Arytera Lautereriana*, showing two large, aggregate rays as dark bands traversing the median portion of the picture. Three inflexions of the rings of growth are shown on each side of the aggregate rays. Some obliquely cut vessels are seen as elliptical, light spots in the area between

the two aggregate rays. Transversely cut vessels are numerous in the normal wood to the left and right of the pair of aggregate rays and appear as light, round or oval spots. The fine lines passing from the top to the bottom of the picture represent the normal, uniseriate rays of the species.

4. Longitudinal section of the wood of *Arytera Lautereriana*, showing the lens-shaped area enclosed between two large aggregate rays. The lens-shaped area occupies a median position and passes from top to bottom of the picture. In it transversely and obliquely cut vessels are represented as light, round or elliptical spots. The long, light bands passing from top to bottom represent vessels in longitudinal section. The innermost, longitudinally cut vessels are shown as partly bending round the aggregate rays which surround the median, lens-shaped area.

5. Transverse section of the wood of *Arytera Lautereriana*, showing inflexions in the rings of growth. The dark area in the lowermost part of the picture is part of a small, brown-coloured patch to which a sapwood indentation was traced. The opacity of the area is due to the presence in the lumina of the cells of a brown substance which gave reactions for tannin. The upper boundary of the dark area defines the boundary of a growth ring. Subsequent rings of growth are inflexed towards the middle of the picture and vessels are absent from the median area in a narrow band passing from the dark area to the top of the picture. The small, irregular dark area just above the lowermost dark segment consists of a cluster of thick-walled, copiously pitted parenchymatous cells. The normal wood of this species is composed of septate fibres, vessels and rays. The cluster of thick-walled parenchymatous cells appears to be abnormal and to result from injury, possibly by insects. The fine, dark lines passing from top to bottom of the picture represent the rays. The light, round areas represent the vessels.

6. Transverse section of the wood of *Arytera Lautereriana*, showing the same section as represented in the preceding picture but a little further towards the centre of the stem. The dark, tannin-containing area partly shown in the lowermost part of the preceding picture is more fully depicted in this picture.

Plate XIV.

7. Transverse section of wood of *Canthium latifolium*, showing two parallel aggregate rays passing from top to bottom of the picture. These aggregate rays are connected with a depression of the sapwood surface and inflexed zones of growth. The normal 1-2 seriate rays are shown on each side of the aggregate rays. The vessels, which are comparatively small, are absent in the two aggregate rays, but plentiful on each side and between them. Wood parenchyma is present, but is not conspicuous in the picture. It is scattered or adjoins the vessels. The wood fibres have very narrow lumina and thick walls, the lumina being as wide as the walls are thick.

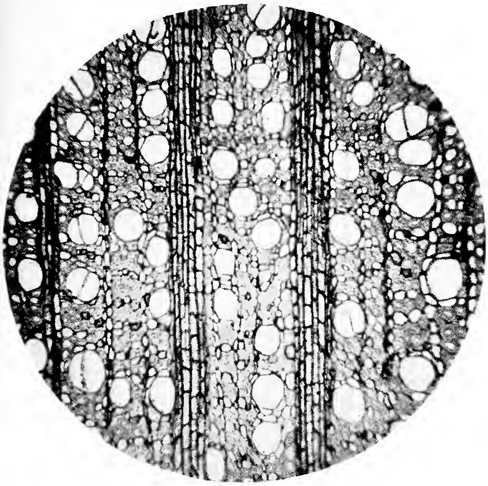
8. Longitudinal section of wood of *Canthium latifolium*, showing two aggregate rays which are associated with a sapwood depression. The two aggregate rays are shown on the right and left sides of the picture, and are characterised by the absence from them of vessels, which are represented as long, light bands. Some wood parenchyma is shown as rectangular cells towards the middle of the picture.

9. Transverse section of wood of *Cryptocarya corrugata*, showing a large aggregate ray situated in the median portion of the picture. The inflexion of the zones of growth in and near the aggregate ray is evident. Further out the aggregate ray terminates in a sapwood indentation. The two dark bands crossing the aggregate ray consist of wood parenchyma, which is arranged in tangential bands. The thickness of the walls of the wood fibres is $\frac{1}{4}$-$\frac{1}{3}$ of the diameter of the lumina, and the pitting of the fibres appears to be confined to their radial walls.

10. Longitudinal section, showing a large aggregate ray in wood of *Cryptocarya corrugata*. The aggregate ray is situated near the middle of the picture. Towards the extreme right and left longitudinally cut vessels are shown. Between the vessels and the large, aggregate ray scattered rays occur.

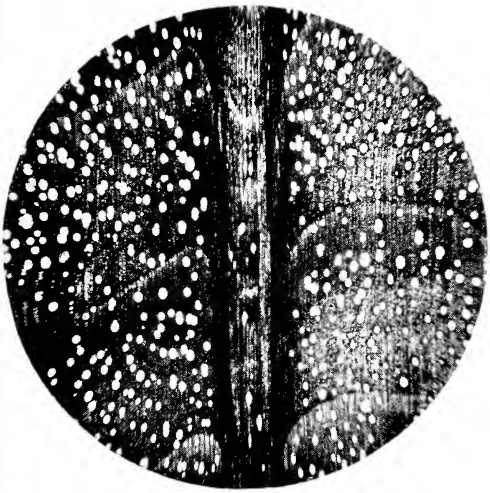
11. Transverse section of the wood of *Casuarina inophloia,* showing a very large aggregate ray accompanied by a pronounced inflexion of the zones of growth. Further out the aggregate ray terminates in a prominent sapwood indentation. Narrow bands of wood parenchyma, which is arranged in tangential layers, are evident in the picture and are shown as rows of cells, some of which are light and others dark. The walls of the wood fibres vary in thickness from one-half to twice the diameter of the lumina. In longitudinal sections, the lateral walls of the vessels are seen to have scalariform perforations.

12. Longitudinal section of the wood of *Casuarina inophloia,* showing a large aggregate ray which is connected with a prominent sapwood indentation. The aggregate ray occupies the median portion of the picture; passing through it in transverse and oblique directions is a number of wood fibres. The tissue on the right and left of the aggregate ray consists of wood fibres, vessels (the large light bands in lower part of picture), many uniseriate rays (small, spindle-shaped areas tapering at each end) and wood parenchyma (composed of rectangular cells).



1. VILLARESIA MOOREI × 35

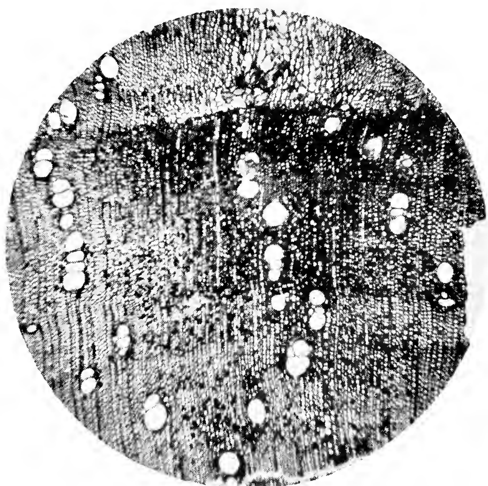
2. VILLARESIA MOOREI × 35



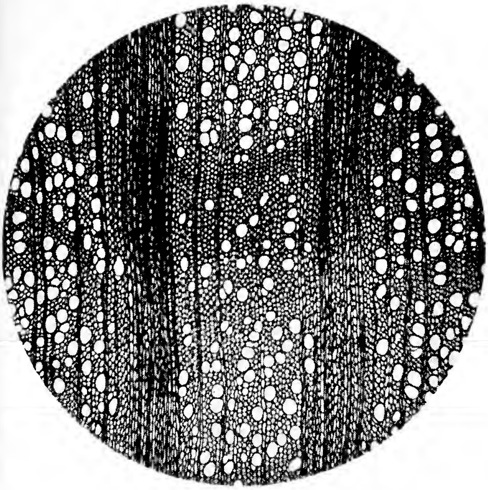
3. ARYTERA LAUTERERIANA × 8·5

4. ARYTERA LAUTERERIANA × 8·5

5. ARYTERA LAUTERERIANA × 35

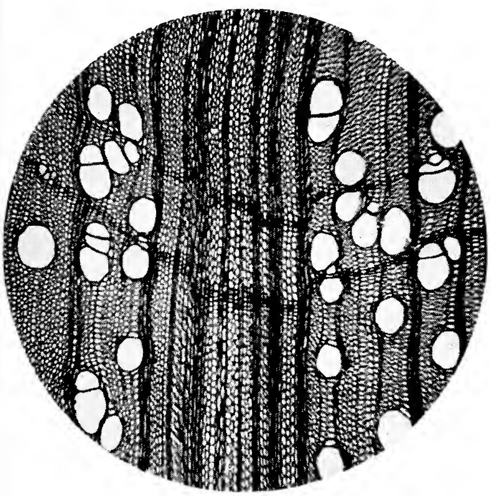


6. ARYTERA LAUTERERIANA × 35



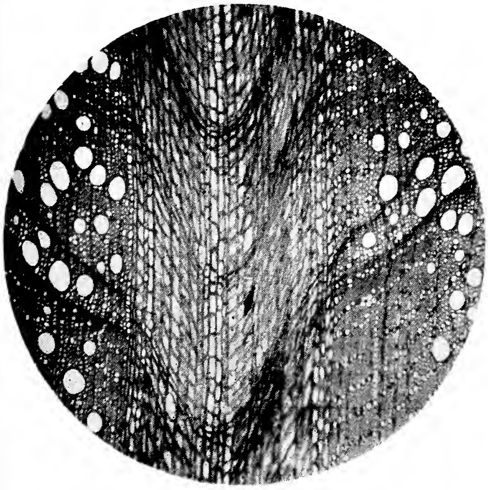
7. CANTHIUM LATIFOLIUM × 35

8. CANTHIUM LATIFOLIUM × 34



9. CRYPTOCARYA CORRUGATA × 35

10. CRYPTOCARYA CORRUGATA × 34



11. CASUARINA INOPHLOIA × 37

12. CASUARINA INOPHLOIA × 36

Solar Phenomenon Observed from H.M.A.S. "Moresby."

(Plate XV.)

BY J. A. EDGELL (Captain R.N.).

(Communicated by Professor H. C. Richards before the Royal Society of Queensland, 26th July, 1926.)

Whilst at sea off the Keppel Islands on the east coast of Queensland, on Wednesday, 4th November, 1925, in position, Lat. 23° 6½′ S., Long. 150° 57′ E., at about 0800, a portion of a halo was observed (Plate XV., Sketch 1), above the upper limb of the sun, apparently reflected on to a semi-transparent and misty cloud. Shortly afterwards the halo was observed below the lower limb (Sketch 2), and at 0815 a complete circle was formed. The phenomenon then extended rapidly and by 0830 was fully developed, as indicated in Sketch 3.

The various rings were distinctly visible from 0830 until 0845, when the outer ones began to fade, and at 0930 a single halo round the sun only remained; this gradually faded, the last portion visible being that below the lower limb, which finally disappeared at 1045. During practically the whole time that the phenomenon was visible, the brightest and clearest portions of the circle were the segments of the original halo immediately close and below the upper and lower limbs.

The colours of the spectum were clearly seen, as shown in the sketches; the large circle with the zenith as centre and the large ellipse were of a faint white colour like white clouds.

The altitude of the sun at 0840 was 47°, and the angular distance of the circumference of the inner halo was 22¼°. The weather was fine, a few cumulus clouds were about, and there was a light easterly breeze.

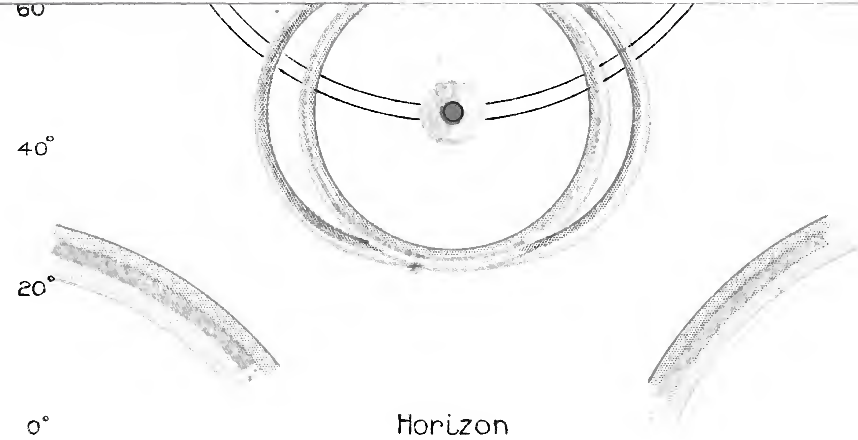
During the night a thunderstorm, which lasted some hours, was observed over the mainland some twenty or more miles away, but the storm did not come out to sea, and the weather both before and after the phenomenon was unusually fine, and the absence of strong wind, which had previously been experienced for some days, most marked.

The barometer was about one-tenth of an inch above the mean average height, and from observations so far made this seems to indicate in general a decrease in the force of the wind in this locality. Further data is necessary, however, before this can be accepted as a fact.

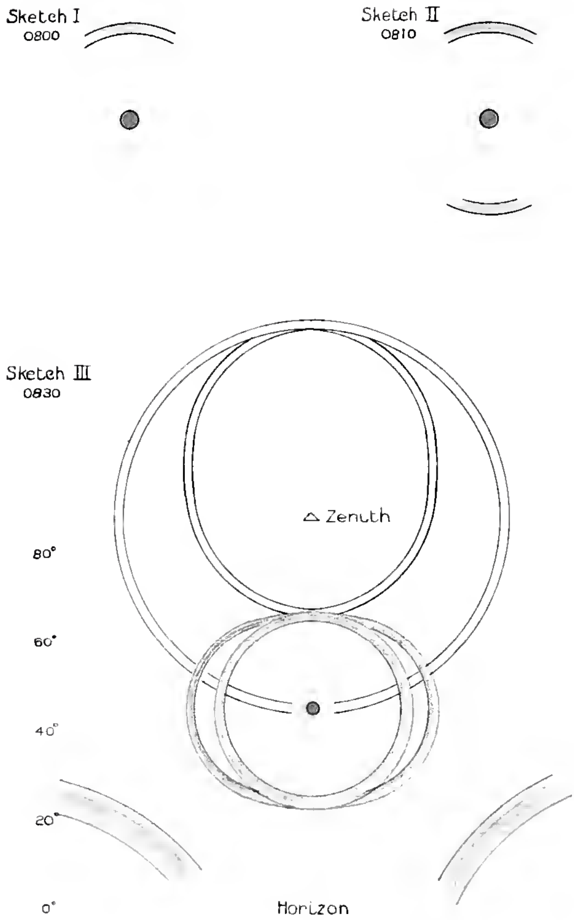
An extract from the meteorological log, covering the period 1600 on the 3rd November to 1600 on the 4th November, is attached.

EXTRACT FROM METEOROLOGICAL LOG KEPT ON BOARD H.M.A.S. "MORESBY"—CAPTAIN J. A. EDGELL, O.B.E., R.N.—AT KEPPEL BAY.

DATE—	WIND.		BAROMETER.		THERMOMETERS.		CLOUDS.		Prop. of Sky clouded—0 to 10.	Weather according to Beaufort Notation.	Visibility of Fog Intensity (See Scale).	SEA SURFACE.		Time of Remark.	Remarks.	Anemometer Reading m.p.h.
Year, 1925. Month, XI.	Direction True (Nearest Point).	Force 0 to 12.	Uncorrected Reading Mb.	Att. Therm. Absolute Scale.	Dry Bulb No.	Wet Bulb No.	Upper.	Lower.				Temp. by No.	Spec. Grav. by No.			
3rd G.M.T. 10 hr. 00 m.	E. by N.	3	1020·2	300	74	70	..	Stationary Cu.	1	b	9	76	11·0	1925	Lightning observed from S.W. to S.E.	10·5
	N.E. ..	3–4	1021·0	302	76	71	..	Stationary N.G.	3	b	5	75	12·0	2330	Wind freshening from S. Lightning to the W...	10·5 12·5
	S. ..	3–4	1025·5	300	72	69	..	Stationary N.G.	8	c	5	73	11·0	0200	Wind increased and backed to E.; sky G.; barometer dropped to 1020·5—0330 wind dropped; sky clouding from N.	..
	Calm ..	0	1021·1	298	73	69	..	North Cu...	4	bc	6	75	12·0	0805	Observed sun-ring subtending an angle of 90°; 10° dist. from sun	..
	E.S.E. ..	1–2	1023·9	300	73	70	A	Cu. / Cu. Nb.	6	bc	8	76	11·0	0830	Four rings visible ..	11·5
	E.S.E. ..	1	1023·2	300	74	69	A	Stationary A-St.	6	bc	8	75	11·0	1045	Last rings (small inner ring) disappeared	..
	E. ..	2	1021·8	300	78	72	A	St. ..	6	bc	7	73	12·0	..	..	..



Solar Phenomenon observed from H.M.A.S. "Moresby." 4 · 11 · 25



Solar Phenomenon observed from H.M.A.S. "Moresby." 4 · 11 · 25

Earlier Palaeogeography of Queensland.

By W. H. Bryan, M.C., D.Sc. (Department of Geology, University of Queensland).

(Text figures, 1-6.)

(*Read before the Royal Society of Queensland, 26th July, 1926.*)

I. INTRODUCTION.

In view of the fact that maps illustrating the distribution of land and water in the approximate position now occupied by Queensland, in one or more periods of the Palæozoic era, have been published by several geologists, notably Benson, David, and Jensen, it might be thought that the presentation of the following notes and maps was unnecessary. However, as a result partly of the different interpretation of the known facts, partly of different assumptions concerning those formations the age of which is in doubt, and partly by the application of different methods of attack, the writer has come to conclusions concerning the positions of the lands and seas of Palæozoic times and the shapes of the respective shore-lines which differ radically in many respects from those views hitherto put forward.

The problems of the Queensland palæogeographer are twofold. Not only must he synthesise all the available data concerning the areal distribution of formations of known age, and present his results in the form of maps which are reasonable explanations of that distribution and which bear a logical historical relationship to the maps of the immediately preceding and succeeding periods, but he must endeavour to account satisfactorily for those large areas of the State which are occupied by rocks the age of which is unknown.

With regard to the latter problem, there are several ways in which these rocks of unknown age can be treated, viz.—

(1) They can be ignored. In this case one map must certainly and several maps will probably be wrong.

(2) They can all be placed (with a query) in every map to which they may possibly belong. This method, while more honest than the first, is not much more satisfactory, for most, if not all, the maps in which they appear must be wrong.

(3) They can be differentiated and assigned to various ages on any slight evidence (other than geographical) available, and the maps constructed to include them.

(4) They can be differentiated geographically and placed upon the maps of those periods, the general geographical schemes of which they seem best to fit.

This last method is legitimate only so long as the unknown formations are not used as evidence in support of the general schemes.

If the third method be employed and ages be tentatively assigned to all formations, then the way in which the doubtful formations harmonise with the general geographical schemes for the periods in which they are placed may be used to some extent as arguments for or against the assumed ages. This is the procedure which will be adopted in the following pages. It must be borne in mind, however, that, whatever method be adopted, the maps when produced can only be regarded as tentative and must remain so, as long as the age of any one of the formations is still in doubt.

In a recent essay to solve the problems of Earth Movements in Queensland, the writer came to certain conclusions regarding the historical distribution of the major epochs of diastrophism.

Such distribution should obviously influence the palæogeography of the period so that we might reasonably expect that—

(1) Any two periods which are not separated by violent unconformities or other evidence of important earth movements should present a similar distribution of land and water; and

(2) Any two periods which are separated by important earth movements should not show similar geographical outlines.

These expectations, that geological continuity will be reflected in geographical similarity, and that a break in geological sequence will be accompanied by a change in geographical outlines, are encouraged by the evidence of those parts of the world the stratigraphy and history of which are known in detail.

Hence, if the writer's published conclusions concerning the time distribution of earth movements in Queensland be accepted, we have a method (though admittedly not a refined one) of checking the palæogeographic maps of the different periods.

As in the writer's earlier work on "Earth Movements in Queensland," the conclusions reached here will be based primarily from evidence within the State. The published palæogeographical maps of the other States will, however, be used to check the conclusions arrived at.

Previous Literature.—Since every statement concerning either the extent, thickness, or age of any deposit in Queensland, and each accompanying geologic map, has a bearing, more or less direct, upon the palæogeography of the State, and since many comprehensive maps, showing the distribution of land and water in the past, include Queensland in their scope, it is patently impracticable to cite all the literature strictly relevant to the subject. Mention, however, may here be made with advantage of a few of the more prominent writings which bear very directly on the palæozoic palæogeography of Queensland, while other important but less direct contributions to the subject will be cited in the sequel.

In the year 1911, Jensen[1] published a paper entitled "The Building of Eastern Australia," which was illustrated by maps showing the supposed land areas, continental shelves, and sea areas of the several periods.

Five years later, Schuchert[2] published a number of palæogeographic maps of Australasia and the Western Pacific area in illustration of his article on "The Problem of Continental Fracturing and Diastrophism in Oceanica."

Although he did not publish an account of the Palæogeography of Australia, Professor Sir T. W. E. David frequently lectured on the subject, with the result that his views are well known to Australian geologists. The writer has been fortunate enough to examine and copy the lantern slides with which Professor David illustrated a lecture on the Palæogeography of Australia, delivered in Brisbane in November, 1919. These have been of great use to the writer, and are especially valuable as expressing the generally accepted views of Australian geologists on the subject at that date.

In the year 1923, Benson[3] published his valuable and most informative paper on the "Palæozoic and Mesozoic Seas in Australasia." The accompanying maps of the Australasian region are the most elaborate so far attempted.

Quite recently, Jensen[4] published a series of articles on the "Palæogeography of Queensland," illustrated by a number of maps. These are, as far as the writer knows, the only palæogeographic maps of Queensland as a unit which have hitherto been attempted.

II. THE PRE-CAMBRIAN CONTINENT.

Before considering the distribution of the lands and seas of the several periods of the Palæozoic era, it is necessary to enquire into the position and extent of the Pre-Cambrian continent—the "foundation block"[5], as J. W. Gregory has it—of Australia.

Two distinct and divergent hypotheses have been advanced:—

(1) The first limits the foundation block of the continent to the western half of Australia. Bordering the eastern coast of this land mass was a very broad continental shelf, and to the east of this again was the deep sea. With the passage of time the eastern shore-line, and with it the continental shelf, migrated to the east, and thus the continent grew, reaching its maximum extent in early Mesozoic times, when it was supposed to have included New Caledonia and Fiji. This view has had many advocates in Australia and has been repeatedly urged by David[6]. It was well illustrated by the maps accompanying Jensen's[7] important paper of 1911 which, to judge by the literature of that time, expressed the general opinion of Australian geologists.

(2) The second hypothesis, and broader view, holds that the Australasian Pre-Cambrian foundation block extended much further to the east—as far, indeed, as that represented by the maximum growth of the alternative hypothesis including, as it did, New Caledonia and Fiji—and that the several systems of Palæozoic deposits were laid down in longitudinal mediterranean seas within this huge continent. Such a view has long been held by many eminent European and American authorities, of whom de Lapparent[8] and Schuchert[9] are respectively representative. The latter writes:—

> "Palæogeographic studies during the past thirty years have been developing the hypothesis that the ancient continental platforms were arranged latitudinally rather than longitudinally as they are now, and further, that their areal extent, including their emerged and submerged portions, was greater than at present. It appears that vast land masses have been fractured, broken up, and more or less permanently taken possession of by the oceans—a history which none exhibits better than the Australia-New Zealand region."

Evidence adduced in recent years, and particularly evidence from Queensland, supports Schuchert's idea, so that Australian geologists incline more and more towards the broader view. This is well illustrated by the fact that Jensen—once an ardent advocate of the first hypothesis—now appears to support the second. The following notes and maps use the great latitudinal extent of our ancient continent as a basal assumption.

It seems, then, that the great majority of geologists are agreed that the Australian continent once extended very much further to the east than the present coast line. But just as geologists are divided on the question as to when this extension was first in evidence, so there are differences of opinion as to when its destruction was initiated by the foundering of the Tasman and Coral Seas. Thus Gregory[10] writes:—

> "The breaking up of the Archæan foundation block began in Cambrian and Ordovician times,"

while Schuchert[11] maintains that the breaking down of the continent began in the Permian period, while, as we have seen, other writers maintain that at this time it had not reached its maximum development.

Although the only known deposits of Pre-Cambrian age in Queensland are the Cloncurry series, there is the possibility, nay probability, that many of our formations of unknown age may belong to the Archæozoic and Proterozoic eras.

J. W. Gregory[12] writes of the Archæan basement as extending to Northern Queensland. Many of our formations of "unknown age" are demonstrably earlier than the Devonian and are almost certainly

Pre-Silurian. Lithologically, these very metamorphosed schists, gneisses, and quartzites certainly resemble Pre-Cambrian rocks of other parts of Australia and of the world generally, much more closely than they do the known Cambrian and Ordovician strata. The only rocks of these latter ages which at all resemble our metamorphics are those of Cooma and Heathcote, the ages of both of which are significantly subjects of dispute.

Nevertheless the presence of Pre-Cambrian rocks in Queensland has always been regarded as a radical view, and the generally adopted attitude is well exemplified by the fact that the Cloncurry series (now proven Pre-Cambrian) was regarded as of Silurian age.

This attitude was largely influenced by the great weight carried by the opinion of R. L. Jack, who frequently stressed the danger of over-estimating the age of formations when using lithological types and degrees of metamorphism as evidence. The principal reason for Jack's warning seems to have been the fact that at that time the Brisbane Schists were regarded as the time-equivalents of quite unaltered fossiliferous rocks of Permo-Carboniferous age. With the discovery that the Brisbane Schists really *were* considerably older than the fossiliferous rocks (from which they are separated by marked unconformities) Jack's argument should have lost weight, but the influence of his opinion remained, nevertheless.

Further, many fossils (chiefly of Permo-Carboniferous age) had been reported from areas occupied in the main by highly folded and metamorphosed rocks. Richards and Bryan[13] have pointed out how, certainly in several cases and probably in most, such fossils were collected from younger unaltered strata block-faulted down into the older metamorphic rocks.

With the proof of a Pre-Cambrian age for the Cloncurry Series, those other series which in the past had been tentatively correlated with them should also, in the lack of evidence to the contrary, be regarded as of Pre-Cambrian age. Thus the Einasleigh gneisses may most reasonably be regarded as of this age, while the Etheridge, Woolgar, Cape River, Charters Towers group, while probably from a higher horizon, can quite reasonably be referred to the same great era. Indeed the author would go further and consider the metamorphics of Hamilton, Coen, Dargalong, Cardross, Dunk Island, Barnard Island, Clermont, Mount Coolon, Normanby, and Gatcombe Head (all of which have almost certainly participated in the great late Ordovician orogeny) as tentatively of Pre-Cambrian age. While this is a radical departure from the present practice, the author feels that in the light of the highly metamorphosed nature of these formations, their similarity to Pre-Cambrian rocks of the Northern Territory and Western Australia, their dissimilarity from the gently dipping and unmetamorphosed strata of known Cambrian age, and the entire absence of fossils, the assumption is less forced than the only possible alternatives,—namely, Cambrian or Ordovician ages.

Since these metamorphics are for the most part altered sediments, and as sediments are generally deposited near the land, it might be expected that a Pre-Cambrian map could be drawn, based on the above assumptions.

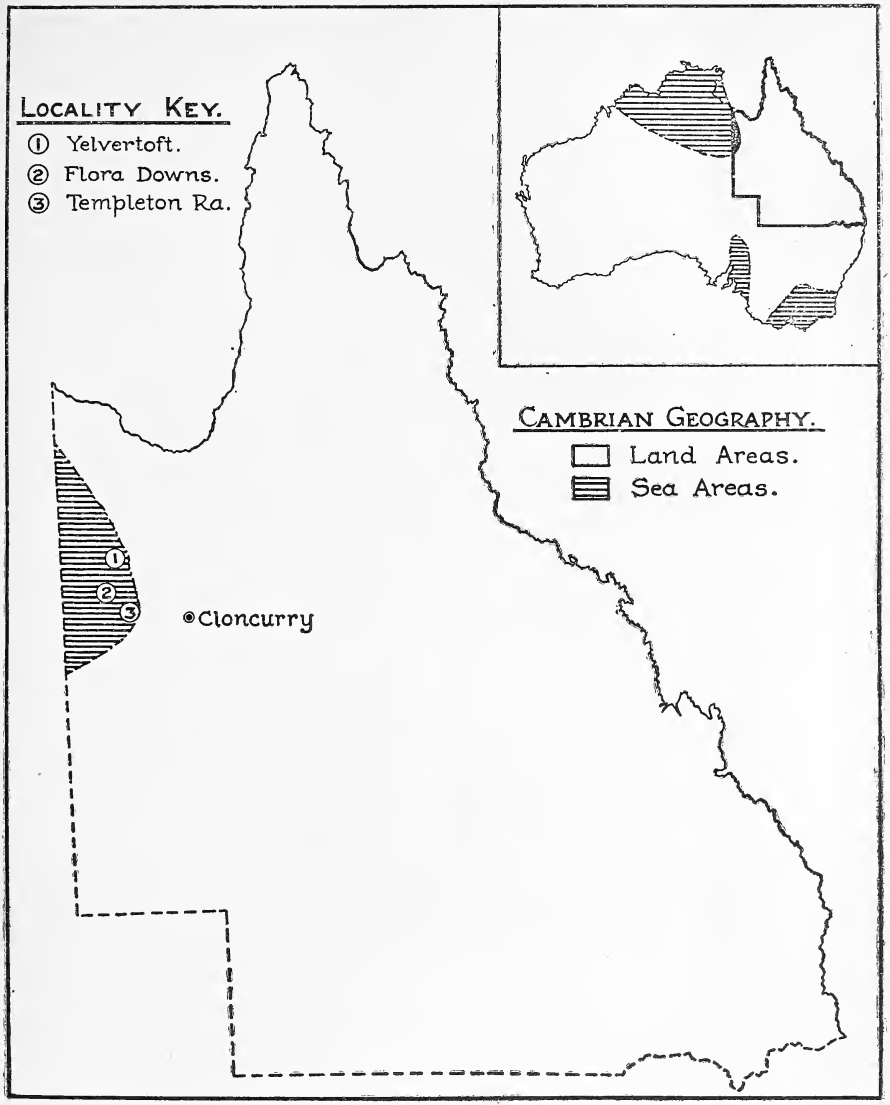
However, the Proterozoic era was of great duration and was in most parts of the world differentiated into several systems separated by orogenic movements of the first importance, which were presumably accompanied by marked geographical changes. It is unreasonable to assume that all those Queensland metamorphics which have been tentatively assigned to the Pre-Cambrian era represent the one system—indeed, at least two systems have been suggested—so that no useful purpose could be served by endeavouring to draw up *one* palæogeographical map to satisfy all the data. If, however, it be granted that the sediments represented were deposited not far from shore lines, it is evident that the Pre-Cambrian continent must have been a very extensive one. The presence of schists and quartzites of ancient aspect in New Caledonia and Fiji supports such a view.

At the close of the Proterozoic era, one of the greatest and most widespread epochs of diastrophism is generally believed to have taken place, with the result that large stretches of Proterozoic sea were elevated into land areas and, unless Australia was an exception to the general rule, much of the great area now represented by our Proterozoic rocks became a land area. Ward[14] has recently come to this conclusion for Central Australia from his study of geology of the Macdonnell Ranges.

III. CAMBRIAN PALÆOGEOGRAPHY.

Until the year 1924 no rocks of definitely Cambrian age had been recorded from Queensland, but in that year Saint-Smith[15] reported the discovery by Mr. Miles (who was at the time engaged on an expedition, the object of which was the discovery of new mineral fields) of Cambrian fossils from the Upper Templeton River (139° 15′ E., 20° 40′ S.) to the west of the Mount Isa silver-lead field. Since that time the area known to be covered by sediments of Cambrian age has been considerably enlarged by further discoveries of fossils at a number of other localities, notably Yelvertoft Station (139° E., 19° 40′ S.), and Flora Downs Station (138° 45′ E., 20° 15′ S.). All of these localities are included, however, in the northern portion of westernmost Queensland.

The discovery of a Cambrian Series in this part of Queensland serves as an interesting illustration of the value of Palæogeography in predicting the presence of otherwise unsuspected formations, for although the official maps of the Geological Survey of Queensland (based, of course, on geological work within the State) do not indicate the occurrence of Cambrian rocks in this position, or even hint at their possible presence, palæogeographic maps published by several authors in various parts of the world have inferred the presence of a Cambrian sea in North-Western Queensland and have shown such in their maps for the period.



Text-figure 1.

The only palæogeographic map of Queensland for the Cambrian period which restricts itself to the confines of the State was published by Jensen in 1925[16]—that is, some time after the discoveries referred to above. This map differs considerably in several respects from that now presented by the writer. In the first place, Jensen's sea stretches very much further to the east than does the writer's, for it includes not only the known Cambrian strata to the west of the Cloncurry (Pre-Cambrian) series, but certain altered sediments in the Gilberton and Etheridge districts. Thus the Cloncurry region is represented as an island washed by the known Cambrian sea on the west and the assumed Cambrian sea on the east. The writer has already given his reasons for assigning the strongly metamorphosed rocks of the Etheridge-Gilbert district (which stand in marked contrast with the unaltered and gently dipping strata of the known Cambrian) to the Pre-Cambrian era, and on the basis of that assumption would regard the Cloncurry region as forming the true eastern shore line of the Cambrian sea.

That this north-western sea was a continuation of that which stretched from the Northern Territory in a south-easterly direction towards the Queensland border is practically certain, supported as it is by the field work of Brown, of Jensen[17], and of Woolnough[18], which indicated geological continuity, and by the palæontological determinations of Dun[19] and of Whitehouse[20], which show that the fossils are typical members of the same *Redlichia* fauna which is found in the Northern Territory and Kimberley, and which Walcott[21] regards as of Lower Cambrian age.

A feature in Jensen's map which raises a very interesting question is that it shows a further area of Cambrian sea in the extreme south-western corner of the State, and the map suggests (though this may not be Jensen's intention) that this area was quite independent of that further north. The writer does not know of any fossils from Queensland itself to warrant mapping in this second sea area, but Jensen's map is a quite reasonable extension of the Lower Cambrian sea of South Australia and Western New South Wales, if it be granted that the glacial unfossiliferous sediments which constitute the series belong to this age, but modern opinion has removed the whole series to the Proterozoic era. But with regard to the known Cambrian sea of South Australia the question remains:—"Was it a southerly extension of the north-western sea, or was it connected only with an ocean in the south?"

The general opinion of geologists would almost certainly support the former alternative. Thus J. W. Gregory[22] writes:—

> "A narrow Cambrian sea must have extended across Central Australia from the Kimberley Goldfield in the north-west, through Temple Downs and the Macdonnell chain in Central Australia, to the South Australian highlands, Central Victoria at Mansfield, and Northern Tasmania."

This hypothesis is geographically expressed by many maps, including those of de Lapparent (1906), Schuchert (1916), Jensen (1911), David (1919), and Benson (1923), and is supported by the palæontological work of Walcott[23], who, after comparing the Lower Cambrian fossils of south-eastern Asia with those of Kimberley, the Northern Territory, and South Australia, concluded that all of the Australian occurrences suggested one faunal province which Walcott concluded might be regarded as a southerly extension of the Mant'o Asiatic province.

In spite of all this weight of opinion, the writer wishes to call attention to the evidence for the possible alternative hypothesis, namely, that the South Australian strata on the one hand and the Kimberley, Northern Territory, North-West Queensland group on the other, may have been laid down in two quite independent seas, the latter of which was connected with South-Eastern Asia and the former with an ocean to the south of Australia.

In this regard, the recent work of Ward[24] is significantly relevant. The strata of Central Australia, which have been considered as of Cambrian age, are divisible into two groups. One composed of quartzites, metamorphic grits and coarse conglomerates sometimes associated with glacial tillites, should now, Ward concludes, "be more properly classified as Upper Pre-Cambrian." These and other undoubted Pre-Cambrian rocks are scattered over an extensive area of Central Australia. The second group is supposed by some to form the lowest portion of what Ward calls "The Lower Palæozoic Sediments." These Lower Palæozoic sediments form a great conformable series of sandstones and dolomitic limestones over 21,000 ft. in thickness and occurring over a great area, which rests unconformably upon the Pre-Cambrian complex. The whole series Ward believes to be of Ordovician age, which was the conclusion reached by the geologists of the Horn Expedition[25]. "No fossils have been found yet in the lower sandstone and quartzite, which are, nevertheless, placed by the geologists of the Horn Expedition and the writer in the Ordovician system. There seems to be no reason for the separation of this lower sandstone from the overlying sediments resting conformably upon it. The nature of the sediments has altered with a change of conditions, but the limestones and sandstones seem to be parts of one great series.

If this conclusion be accepted, the absence of Cambrian beds above the Pre-Cambrian complex follows, since the lower sandstone rests directly upon the gneisses and schists."

Chewings[26] regards the lower portion of the series as Cambrian, and "feels fortified in assigning this age by the discovery of Cryptozoon remains." However, doubt has been thrown on the value of this genus for stratigraphical purposes and, further, Ward has discovered Ordovician fossils from what he regards as the same horizon as that in which Cryptozoon was discovered. Ward's consequent conclusions are that—

> "Following upon the elevation of the central region, before the opening of the Palæozoic era, there was prolonged denudation, which seems to the writer to have extended throughout the Cambrian period."

If Ward's conclusion be accepted, we see that the upholders of the continuous sea hypothesis have not only lost a valuable connecting link, but have in its place an important land barrier with which to contend.

Further, the shortest distance between the most southerly of the northern occurrences (Elkedra Station) and the most northerly of the South Australian localities from which fossils have been collected (Blinman) is 670 miles. While it is possible that these points were connected by a narrow sea in which the central Australian landmass formed either a large island or an extensive peninsula projecting from either the western or eastern shore line, no direct evidence of such an arrangement is at present available. In these circumstances the safest course seems to be to restrict the Cambrian Sea to those portions of Australia where there exists positive evidence of its presence.

IV. ORDOVICIAN PALÆOGEOGRAPHY.

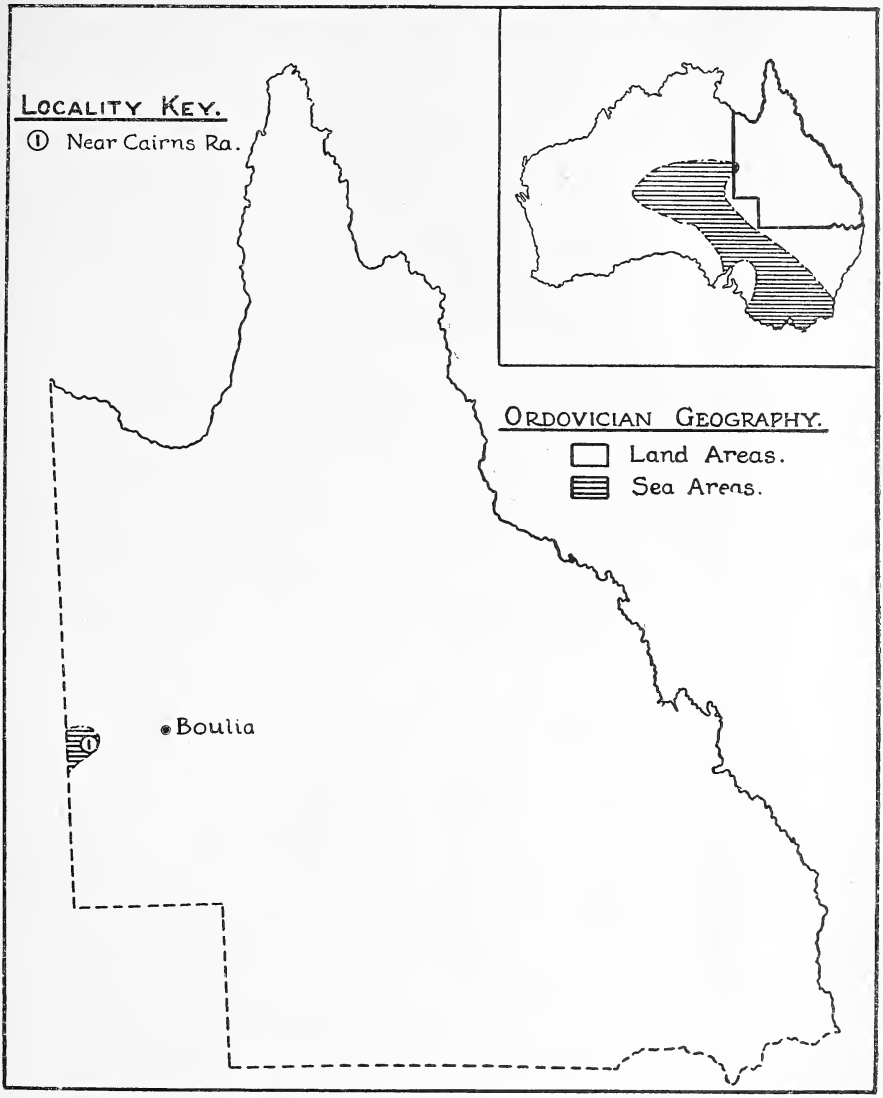
The palæogeographic maps of Australia for the Ordovician period are at variance in several important respects, and the map now presented by the author adds to this diversity. It may be pointed out, however, that the accompanying map agrees more closely with those interpretations found in the more comprehensive maps of de Lapparent and Schuchert than it does with the more specialised local maps of David and Benson, while it differs most of all from Jensen's (1925) map of Queensland. Of the Ordovician palæogeography, Benson[27] writes—

> "The coastal zone now passed through western Tasmania, Victoria, and New South Wales, bending north-eastwards into Queensland."

This bend to the north-eastward is well shown in Benson's map No. 3 and in the Ordovician map illustrating David's 1919 address. The only evidence for this great arm of the sea stretching into Eastern Queensland is stated by Benson as follows:—

> "In the north-eastern corner of New South Wales and extending thence into Queensland are the very altered phyllitic rocks known as the Brisbane Schists; and these, together with some slaty rocks near Rockhampton, contain phosphatic minerals which, in the absence of better evidence, has caused them to be grouped with the Ordovician rocks of Victoria."

Richards and Bryan[28] have advanced reasons for assigning the upper portions of the Brisbane Schist series and its equivalents to the Devonian period. Further, the writer[29] has argued that as there is no sign of unconformity within the series, and as the important late Ordovician orogeny appears to have been pronounced throughout Eastern Australia, the whole of the Brisbane Schist series may reasonably be regarded as Post-Ordovician. Hence the lower portion of the Brisbane Schists would be Silurian in age. If these conclusions be accepted, there is no need for the provision of the north-eastern arm of the Ordovician sea referred to above, and the palæogeography of the period is thereby simplified.



Text-figure 2.

Jensen (1925) draws one map for the two periods—Ordovician and Silurian. Since the map of the writer for the Ordovician period differs extremely from that for the Silurian period, it is difficult to institute comparisons with Jensen's one map. The author does not agree with Jensen's statement that the Silurian and Ordovician are best considered together, for these periods were separated by one of the most important and widespread epochs of diastrophism in the history of Eastern Australia; nor does he subscribe to the further statement that during these two periods there were probably marine conditions over much of the State, if not over the greater part. Indeed the writer's interpretation is that by far the greater part of the State was a land area in each period. Jensen's main reason for advancing the view of marine conditions in Northern Queensland during the Ordovician period is based on his assumption of an Ordovician age for the group of formations which he includes in his "Herbertonian Series." These the author would, for reasons already given, assign to the Proterozoic era. The southern part of Jensen's Ordovician sea is based, like the north-eastern sea of Benson, on the assumption that the Brisbane Schists are Ordovician in age.

Not only does the author's map replace the extensive sea areas placed in Eastern Queensland by other writers, by a vast land mass, but, on the other hand, it replaces in part the generally accepted land areas of the west of Queensland by the sea. This is done for the following reasons:—

In 1896, in a "Note on the Discovery of Organic Remains in the Cairns Range, Western Queensland," Jack[30] referred to fossil specimens in which Etheridge "recognised two undoubted *Orthoceratites*," which had been found in far-western Queensland, "on the east side of the Cairns Range, say twenty-five miles east of the border of this colony, latitude 23 deg. south. . . ." Of these Jack wrote, "Orthoceras is evidently by no means uncommon among the Silurian rocks on the South Australian side of the border, six or seven species having been recognised. . . ." Jack then proceeded to point out that while one school of South Australian geologists, notably H. Y. L. Brown and Chewings regarded the beds containing the Orthoceratites of Silurian age, the other school, led by Professor Tate, regarded them as of Ordovician age. This explains why Jack, having referred the Orthoceratites from Queensland to the Silurian age (as shown by the quotation above), makes later in the same paper the following statement:—

> "It is reasonable to suppose that the Queensland *Orthoceratites* will turn out to belong to the same horizon (Ordovician)*, which has yielded fossils of the same class in adjacent parts of South Australia."

Cameron[31] gives a little more detail concerning the small fossil collection referred to above. He writes of them:—

> "They were identified by Mr. R. Etheridge, junr., of the Australian Museum, as (1) *Orthoceratites* sp. ind., (2) *Actinoceras* (beaded siphuncle of) sp. ind., (3) Univalve and bivalve (casts and impressions)."

The determination of *Actinoceras* is important as eliminating the possibility of the beds being of Cambrian age. Quite recently Dunstan[32] has collected from the same localities further specimens of the beaded siphuncle of *Actinoceras* associated with small Pteropods and Trilobites. The latter are at present awaiting determination.

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* The brackets are placed there by Jack, not by the present author.

To return to the question of the age of these so-called Cairns Range fossils. We have seen that Jack and Etheridge came to the conclusion that they could be most reasonably correlated with the Orthoceratites beds of Central South Australia, but that at that time a controversy existed as to whether these beds were of Ordovician or Silurian age. In the year 1899 the Geological Survey of Queensland published a map in which a large area of North-Western Queensland, including the Cairns Range area, was mapped as Silurian. The author has been unable to discover any published reason for this, and inquiries at the Geological Survey Office were equally fruitless. The most reasonable hypothesis seems to be that the Silurian age was based, through the Cairns Range fossils, on the supposed Silurian age of the Central Australian beds containing Orthoceratites, the real age of which beds was still a matter of controversy.

But the controversy has long been settled by the definite proof that the Central Australian beds were of *Ordovician* age, and the fact that no Silurian rocks have been found in South Australia is now accepted by all geologists. Consequently the Cairns Range fossils should now be and should have been for a long time past regarded as of Ordovician age. This has not been done, and later official geological maps of Queensland have perpetuated the error. One important result has been the mapping by all Australian palæogeographers of a special arm of the Silurian sea to accommodate the deposits under discussion, and the omission to provide for them in maps of the Ordovician period. A significant fact is that they fall quite simply and naturally into the Ordovician map of the author.

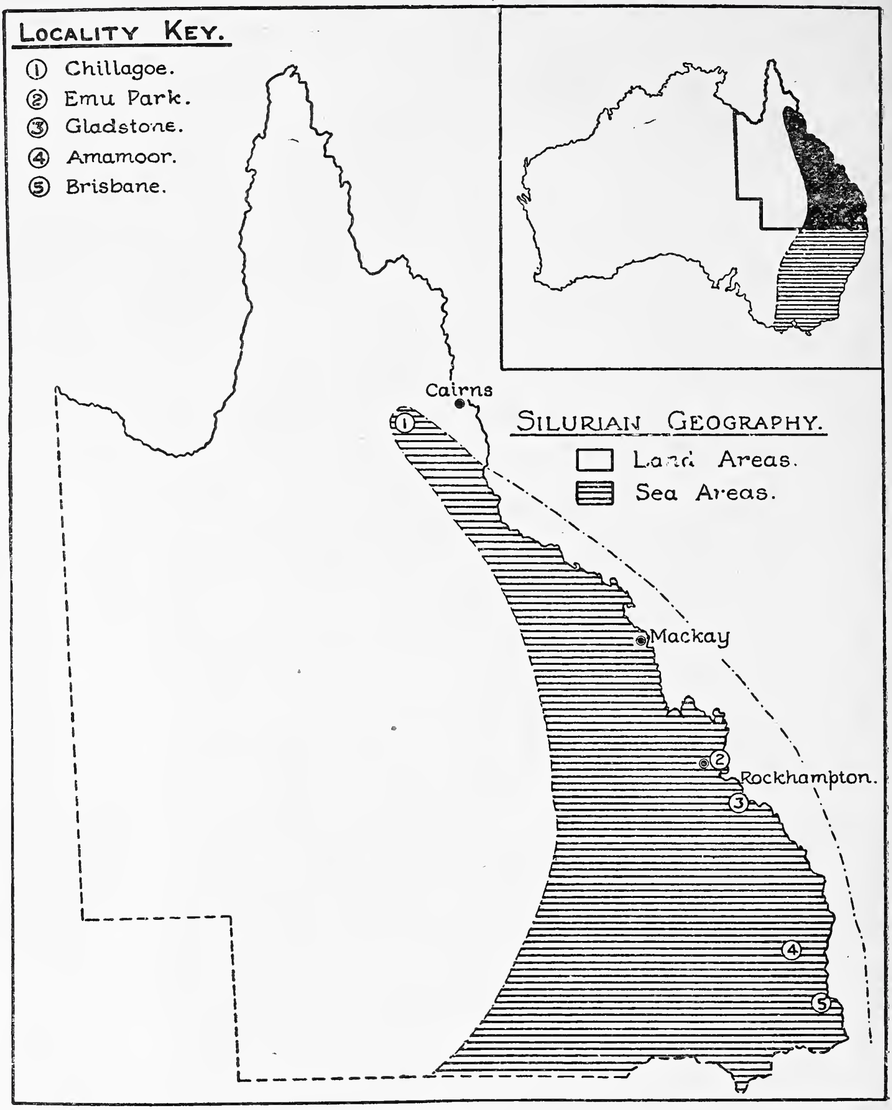
With regard to Central Australia, Ward[33] writes:—

> "A subsequent transgression of the sea, in Ordovician time, brought about the deposition of an immensely thick series of sediments. . . . The Ordovician sea spread far to the southward and westward."

A comparatively slight addition to this extensive Ordovician sea includes the Cairns Range deposits within its scope.

V. SILURIAN PALÆOGEOGRAPHY.

The various maps depicting Queensland in the Silurian period differ considerably among themselves, their only point of resemblance being that they all show a sea area in North-Western Queensland, usually in the shape of a long deep pocket projecting north-westwards from New South Wales. With all these the author disagrees, for they are based on the assumption that a Silurian series exists in North-Western Queensland. The sole evidence for this is that of the fossils from Cairns Range, which the author has already given reasons for assigning to the Ordovician period. With the dismissal of this supposed Silurian series the geography of the region becomes very much simpler, for the long embayment is no longer necessary.



Text-figure 3.

The only undoubted Silurian rocks in Queensland occupy a small area about Chillagoe. All maps of the period must necessarily account for this area. But along with this fact there seems to have gone in the construction of maps of the period the assumption that no other Silurian formation could exist further to the south in Eastern Queensland. Thus various devices have been resorted to in order to represent Chillagoe as a marine area and the rest of Eastern Queensland as land.

The author has already pointed out his reasons for assigning the lower portions of the Brisbane Schist series and its equivalents, the Coff's Harbour series to the south and the Amamoor series and the Gladstone series to the north, to a Silurian age. If the author's suggestion be accepted as a working hypothesis, we have the data for constructing a sea from Coff's Harbour in North-Eastern New South Wales in a north-north-westerly direction as far as Emu Park near Rockhampton. Such a sea could be simply linked up with the Silurian sea of New South Wales. Its relationship with the Chillagoe sea to the north is, in our present state of ignorance, pure speculation. In this case the simplest procedure is probably the safest, and the simplest procedure is to extend the Coff's Harbour-Emu Park sea to the north as far as Chillagoe.

The map of the period which then presents itself stands in marked contrast with those of both the Cambrian and Ordovician periods, which had much in common. In the two latter we saw evidence for considering Queensland, as a whole, a land area with mediterranean seas forming its western border. In the Silurian map the western seas have disappeared, but a great longitudinal syncline has made its appearance in the east. This is the earliest evidence of what Schuchert[34] has termed the Tasman Geosyncline, which, however, Schuchert thought had its origin in the Ordovician period.

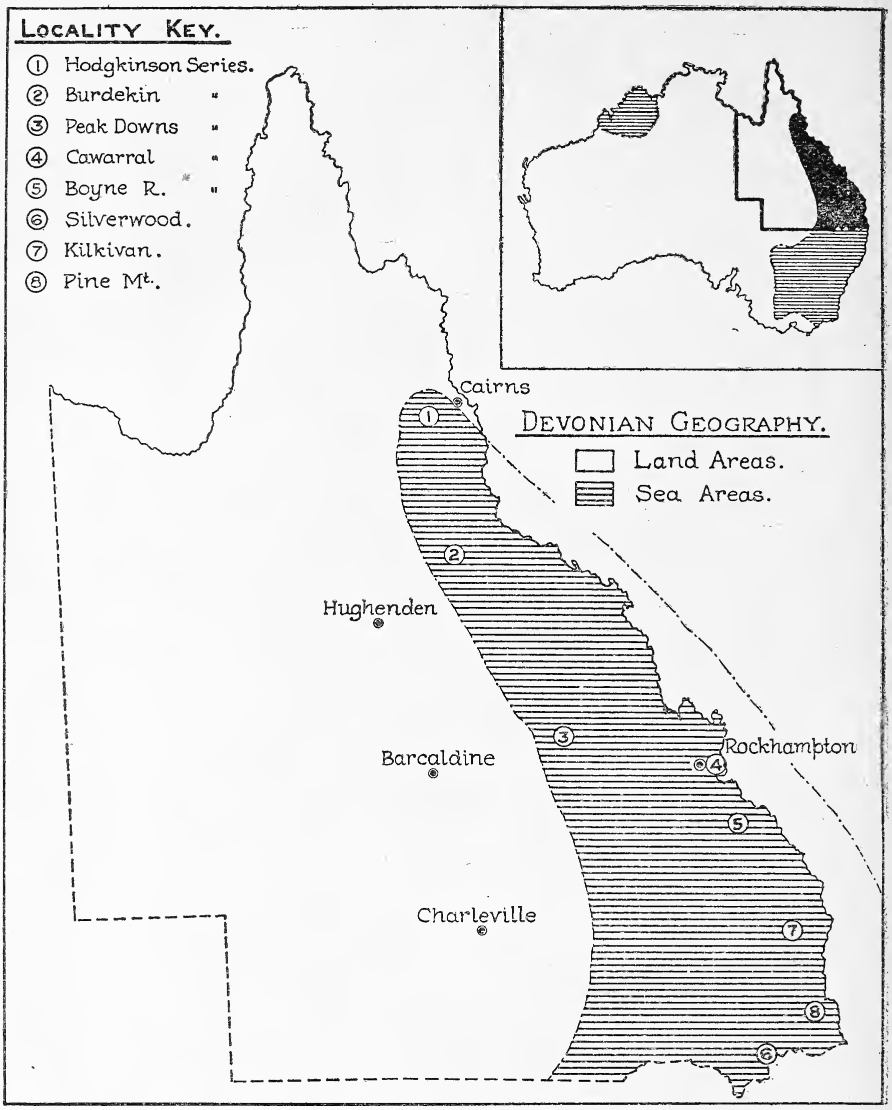
The remarkable geographical transformation which appears to have taken place between the Ordovician and the Silurian period was doubtless the result of those major orogenic movements at the close of the Ordovician period, which not only affected all Eastern Australia, but formed one of the most important diastrophic epochs of the world as a whole.

VI. DEVONIAN PALÆOGEOGRAPHY.

All the maps of the Devonian period which include Queensland in their scope are in general agreement so far as their main features are concerned, and that now presented by the author does not depart radically from the generally accepted opinion. The reason for this unanimity is that in the Devonian period we meet, for the first time in Queensland, extensive developments of fossiliferous rocks.

A remarkable feature about the map of the Devonian period for Queensland is the marked parallelism it presents to the Silurian palæogeography as interpreted by the author. This might reasonably have been expected, for there seems no reason to believe, so far as Queensland is concerned, that the two periods were separated by earth movements of sufficient intensity to bring about marked geographical changes.

The Devonian deposits appear to have been laid down in the same great eastern geosyncline that was first noticed in Silurian times. The "Tasman Geosyncline" provides a remarkably close parallel with the great "Appalachian Geosyncline" of North America. In their geographical positions with reference to the present coast-lines, in their longitudinal direction, in their age, and in their relationship to the eastern, now vanished, border-lands of "Appalachia" and "Tasmantis" respectively, they are strikingly similar.



Text-figure 4.

The northernmost point of this great geosyncline is not easy to decide. It certainly extended as far as the northern limits of the Burdekin series, but it may have reached much further. Although the view of the Queensland Geological Survey at the present time is that the considerably disturbed and metalliferous beds of the Hodgkinson area containing *Lepidodendron australe,* and the slightly disturbed beds of Newellton, in which Stirling[35] found *Rhacopteris,* constitute one and the same (Carboniferous) series, the author has, in a previous publication[36], advanced the hypothesis that these are in reality two series, the former belonging to the Devonian and the latter to the Carboniferous period. If this be accepted, the northern limit of the Tasman geosyncline is considerably extended.

Further north, in the Pascoe River area, Morton[37] discovered a series of strata containing Lepidodendroid stems and the genus *Cordaites,* which Walkom assigned to the Carboniferous period. The author has accepted this opinion and, consequently, places the Pascoe River beds in his map of the Carboniferous period, but it seems possible on the evidence so far available that the series may be of the same age as the Hodgkinson beds, and may thus belong to the Devonian period. If this were so, the Devonian geosyncline would need to be extended still further to the north.

The fact that the only fossils found in the Hodgkinson beds (and in the Pascoe River beds) were plant remains, points to the proximity of the land, and even suggests that these beds may have been laid down under lacustrine conditions in a wide meridional valley which was a structural continuation of the geosyncline.

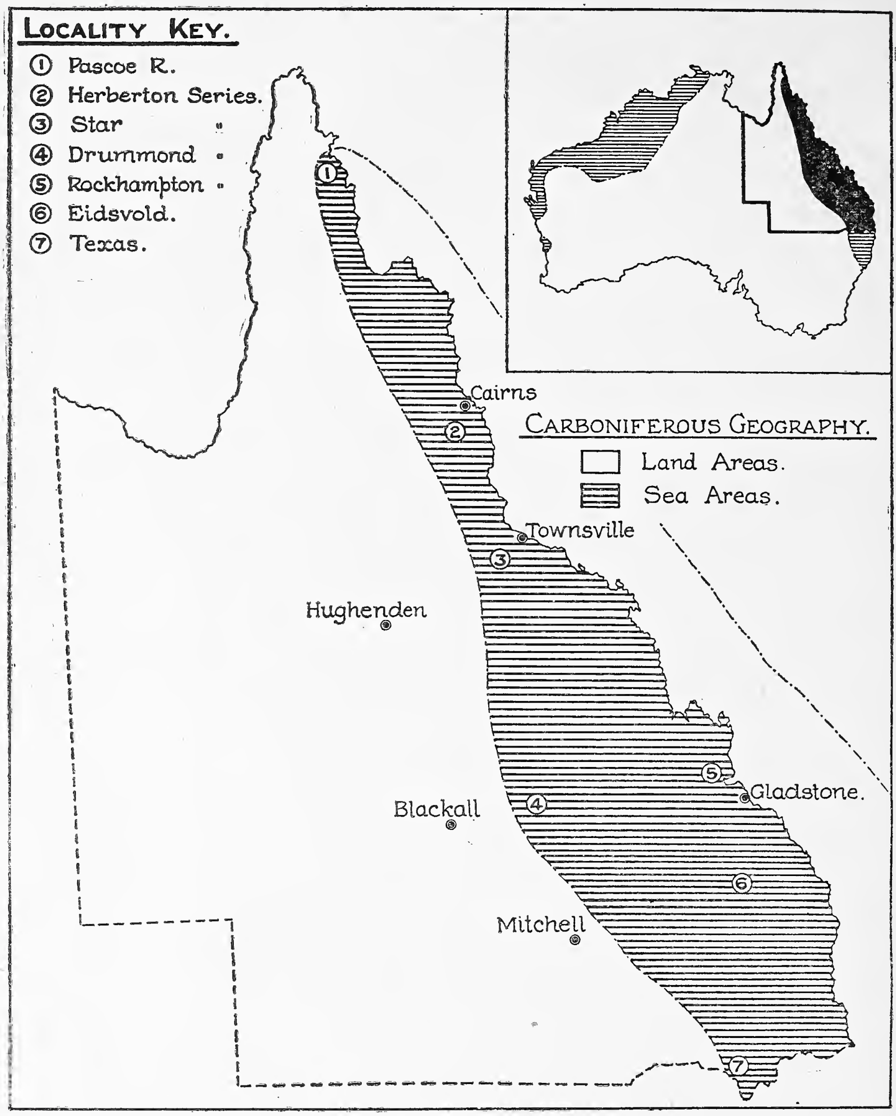
Turning now to Southern Queensland, several facts of interest present themselves. In the first place, it will be seen that the geographical distribution of the Coff's Harbour, Brisbane Schist, Amamoor, and Gladstone series (all of which are usually regarded as of the same age) is such as to support Richards and Bryan's conclusions that the upper portions of these series were laid down in a Devonian sea.

An important point which distinguishes the map now submitted from that presented by Benson is that in the former there is no trace of the land barrier which, in the latter, separates the Devonian sea of south-easternmost Queensland from that of New England. This apparent divergence of opinion is due to the fact that since the publication of Benson's maps, Richards and Bryan[38] have advanced a number of reasons for regarding the Silverwood limestone of Southern Queensland as the same horizon as the Nemingha limestone of New England. The fauna of both are in no wise typically Devonian, but have a distinctly Silurian flavour, which suggests that they may really belong to a lower horizon than the "Middle Devonian," to which Benson has assigned the New England occurrences.

VII. CARBONIFEROUS PALÆOGEOGRAPHY.

The Carboniferous maps of Queensland hitherto published do not differ radically from each other, except in so far as the older maps show deep sea to the east of the zone of deposition, while the more recent and the more comprehensive maps show an eastern land mass, and this remark can be applied generally, of course, to all the Palæozoic periods with the exception of the Permo-Carboniferous.

With regard to the present map, it should be noted that while the Pascoe River area has been included, it may, as pointed out in the last section, have been more properly placed in the map for the Devonian



Text-figure 5.

period. On the other hand, the Hodgkinson area, which was placed in that period, may, if Dunstan's supposition is correct, be more properly included in the Carboniferous map.

The position of the eastern shore line forms an interesting problem. It may be that the area now occupied by the Gladstone, Amamoor, Brisbane Schist, and Coff's Harbour series was at this time land, in which case the Carboniferous sea was considerably restricted in the southern half of Queensland and in New South Wales. On the other hand, these masses may be the remnants of a denuded geanticline, raised as the result of the late Mesozoic orogeny, which has lost the Carboniferous (and higher) sediments which once covered it. On the data he has been able to collect, the author is unable to come to a definite conclusion on this important point.

In his study of the earth movements of Queensland the author concluded that a very important epoch of orogenic movement, comparable with the important Schickshockian Revolution of North America, took place in Queensland late in Devonian times. Under these circumstances one would expect to see the results of this movement reflected in the geographical distribution of the land and water units of the following period. This expectation has not been realised in the present study, for the map of the Carboniferous period shows a marked parallelism with that of the preceding period. It may have been, of course, that, concomitant with the deepening of the Tasman geosyncline, the Devonian strata lying upon it were folded and crumpled, but that no new land area was produced. Such an hypothesis, if advanced, for this particular case would really be, of course, an application of James Hall's well-known theory of mountain building, for Hall contended that all those highly involved convolutions which go to make up a major geanticline were impressed upon the sediments, while the geosyncline in which they were formed was sinking as "a very natural and inevitable consequence of the process of subsidence."[39]

VIII. PERMO-CARBONIFEROUS PALÆOGEOGRAPHY.

The use of the term "Permo-Carboniferous" in this work is in accordance with the policy of geologists of this State. Although it is a common custom elsewhere in Australia and particularly in New South Wales to abandon it in favour of Permian, the tacit assumption that the problem of the age of the Permo-Carboniferous deposits has been solved is without the solid foundation of fact. Opinion as to where, in the Permo-Carboniferous deposits, the line to separate the equivalents of the Carboniferous and Permian periods should be drawn, is still divided; indeed, some years ago, J. W. Gregory[40] showed that a good case could be made for assigning by far the greater part of our Permo-Carboniferous deposits to the Carboniferous period.

During the past few years evidence has been accumulating in Queensland, no item of which is in itself conclusive but all of which point in the same direction—namely, towards Carboniferous rather than towards Permian. It is not the intention here to present this evidence in detail, but it may be said that it is concerned with the geological and geographical ranges of the coral genera *Trachypora*, *Cladochonous*, and *Monilopora*, and the plants *Sphenophyllum speciosum* and *Gangamopteris cyclopteroides*. In conversation with the writer, Dr. Whitehouse has assured him that conclusions derived from his study of the Cephalopoda and Brachiopoda point in the same direction, and suggest that those authors who use the term "Permian" in place of "Permo-Carboniferous" assume more than the facts warrant. Until the problem is finally and satisfactorily settled the author would urge that, although it is admittedly clumsy, the term "Permo-Carboniferous" be retained.

In Queensland, as in New South Wales, there is evidence of an alternation of marine and lacustrine conditions during the Permo-Carboniferous period. In both States there appear to be two important marine stages and two important stages of fresh-water deposition. But in both States there were additional minor changes from marine to lacustrine conditions actually within these stages. These fluctuations appear to mark the closing epochs of the great Tasman geosyncline, which had played an all-important part in Australian geography since Silurian times. The alternations of sea and lake conditions point to a very shallow depression, and the widespread area over which Permo-Carboniferous deposits are found suggests extensive transgressions over a continent of low relief. This picture is very different from that drawn by Griffith Taylor[41], who wrote—

> "In Permian times there was a long and rather narrow depression extending from Cooktown (Queensland) to Cape Howe (New South Wales). . . . ."

In the accompanying map the author has not attempted to separate the various stages of the Permo-Carboniferous deposits in Queensland, but has endeavoured to show the minimum limits reached by the marine transgressions and the extent covered by swamps and lakes during the period. The map forms a natural connecting link between Palæozoic geography and the influence which was still exercised by the old geosyncline on the one hand, and the Mesozoic and its extensive lacustrine deposits on the other. It thus appears to uphold the author's contention, published in these proceedings, that[42]—

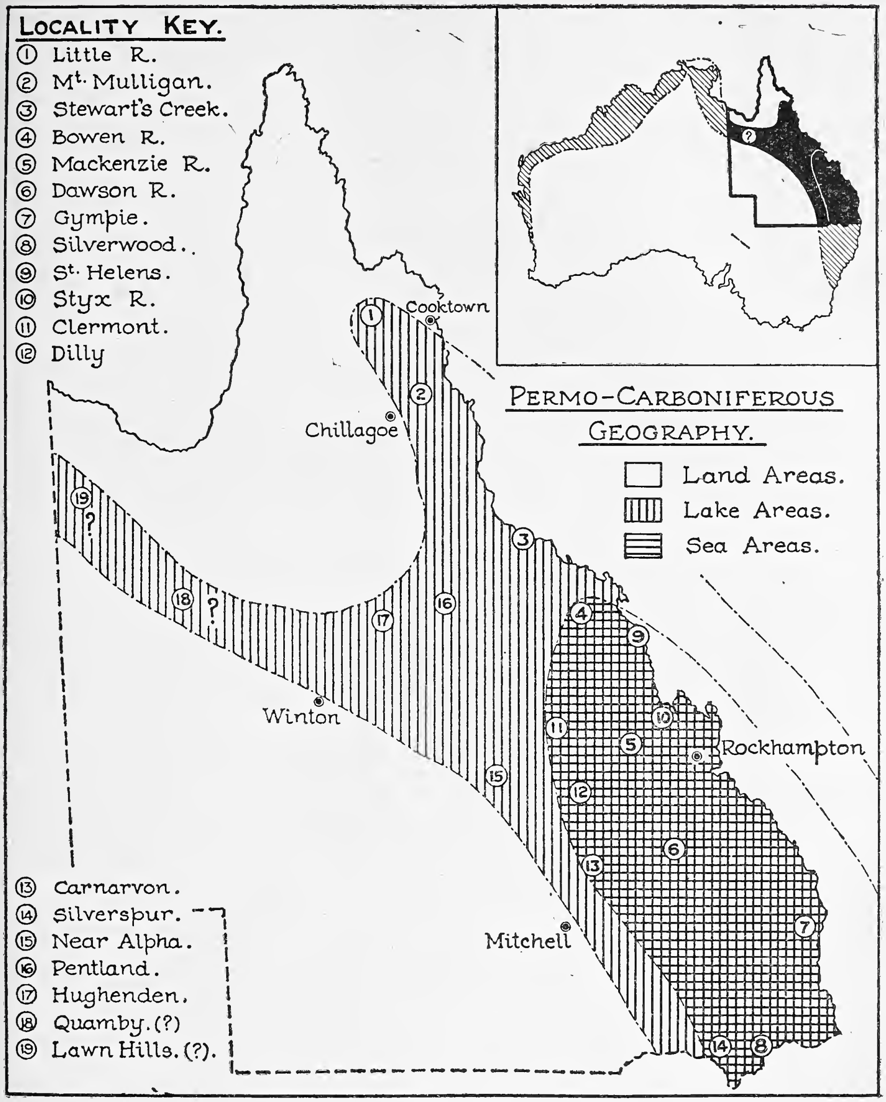
> "There was no folding of any importance in Queensland at the close of the Palæozoic era,"

but that—

> "The movement succeeding the Permo-Carboniferous period was one of general epeirogenic uplift."

In order to account for the difference between the Permo-Carboniferous fauna of Western Australia and that of Eastern Australia, reference has often been made to a great mountain chain which is supposed to have extended in a meridional direction right across Australia at this time. Thus David and Sussmilch[43] write:—

> "Here one must emphasise the extraordinary effectiveness of the Darwin to Adelaide mountainous land barrier which in 'Permo-Carboniferous' or Upper Carboniferous time so completely isolated the West Australian and Northern Territory seas on the one hand from those of Eastern Australia on the other."



Text-figure 6.

The author, while he admits the necessity of a barrier of some description to account for the geographical distribution of the Permo-Carboniferous fauna of Australia, knows of no evidence whatever in support of the hypothetical mountain range. No traces or remnants of such a range have been found, and the structural geology of Central Australia with its pronounced E.-W. trends is decidedly antagonistic to such a view. The absence of any important orogenic movements in Australia separating the Lower Carboniferous cosmopolitan fauna from the overlying provincial faunas discounts the suggestion of mountain-building at such a time. Yet it is reasonable to suppose that the barrier—whatever shape it may have taken—was created after the time of the cosmopolitan fauna and before the appearance of the provincial faunas. The Permo-Carboniferous palæogeography, both of Queensland and of Australia as a whole, is suggestive of transgressions over a land of low relief, and the great extent of the lacustrine deposits of the period supports such a view. It seems, then, that there is little real evidence in favour of the great hypothetical mountain chain, but the author is of the opinion that an extensive desert barrier in a land of low relief would be equally as effective. Such a barrier needs no assumptions involving orogenic movements of great intensity over a large area, and the evidence of land ice of this age found over considerable portions of the continent makes the assumption of a cold desert barrier a not improbable one.

IX. CONCLUSION.

1. Attempts have been made in the accompanying six maps of Queensland to represent the approximate distribution of the land and sea areas in each of the Palæozoic periods.

2. The maps differ radically from most of the palæogeographic maps of Queensland which have hitherto appeared.

3. The major differences are determined by the following assumptions:—

(i.) That the Palæozoic continent extended far to the east of the present coast-line;

(ii.) That the very metamorphosed schists and gneisses of Northern and Central Queensland are all of Pre-Cambrian age, although they may represent several different horizons;

(iii.) That the Brisbane Schist and equivalent Series are made up of a Silurian series conformably overlain by a Devonian series.

4. As each period represents a very long span of time, it is almost certain that numerous geographical changes will take place within the period, some of them of considerable importance. Hence, as no good purpose would be served by attempting to define minor embayments and ephemeral islands, the coastal outlines have been made as sweeping as possible.

5. In each case these sweeping coast-lines enclose the known deposits of the period as closely as possible. Consequently, all the seas mapped must be regarded as minima and the lands as maxima.

6. The localities furnishing the data on which the maps are chiefly founded are shown by numbers enclosed in circles. The key to these numbers is placed on each map.

7. In order to supply reference points, a few of the larger towns near the supposed coast lines are shown in each map.

8. The inset maps of Australia will, it is hoped, serve two purposes. They are meant to show the relationship of the Queensland deposits to the continent as a whole, and they should also serve to show the alterations in the palæogeography of the neighbouring States necessarily consequent upon the acceptance of the author's views.

9. The information on the inset maps of Australia, where it does not rest upon the author's interpretation of the Queensland palæogeography, is based on the maps of Benson[44], David[45], Sussmilch[46], and Walkom[47].

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Later Palaeogeography of Queensland.

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(*Read before the Royal Society of Queensland, 26th July, 1926.*)

Text Figures 1-4.

I. INTRODUCTION.

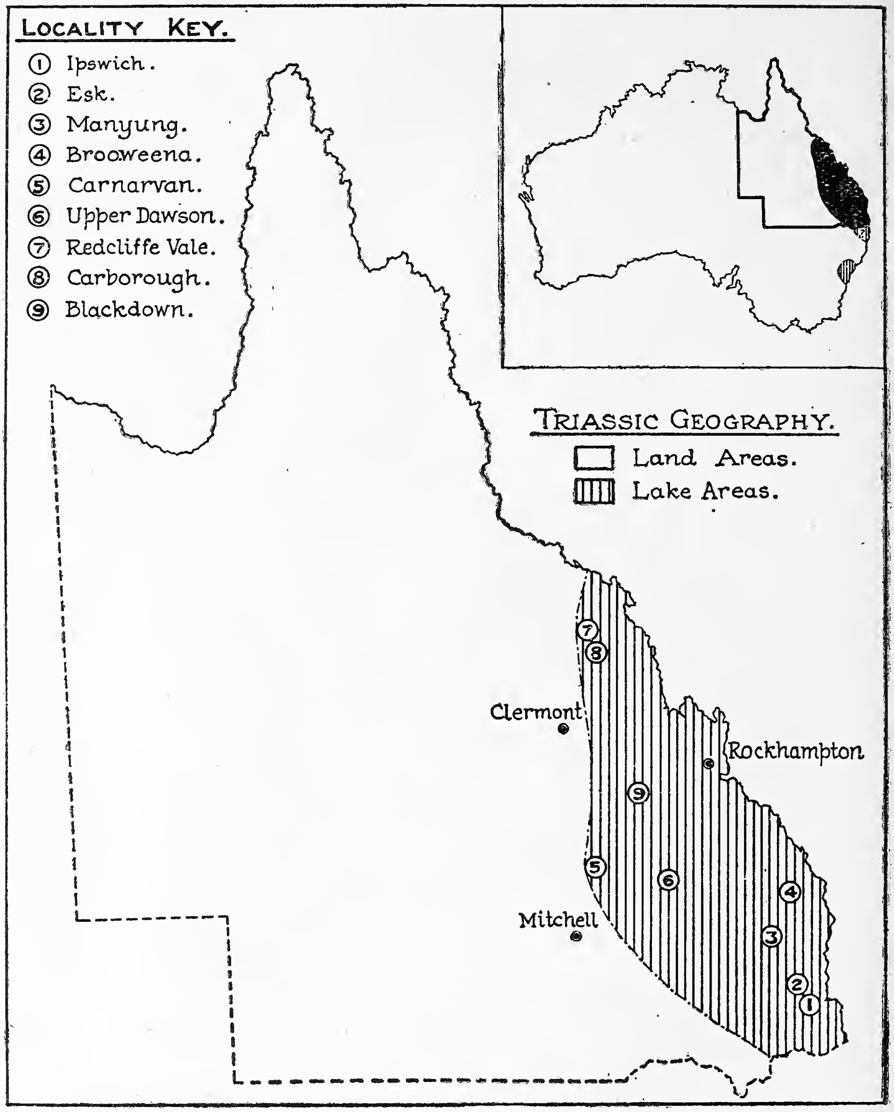
The following series of palæogeographic maps of the Mesozoic and Kainozoic eras has been prepared uniformly with and in continuation of the set of maps illustrating the distribution of sea and land in Queensland during the Palæozoic era lately submitted by one of us (W.H.B.)[1] to this Society.

Previous Literature.—Wallace[2], Neumayr[3], Skertchly[4], Hedley[5], Jensen[6], Schuchert[7], Walkom[8], and Benson[9] have all published palæogeographic maps of, or including, Eastern Australia, for one or more periods, while quite recently Jensen[10] has published a series of maps restricted to the Queensland area.

II. TRIASSIC PALÆOGEOGRAPHY.

The main point of difference between the map of Queensland for the Triassic period here presented and those hitherto published is the much greater extent of the lacustrine area in the south-eastern portion of the State. This difference does not necessarily indicate a difference of opinion from the earlier workers, for the extension is based on data acquired only recently. Since Walkom's map for the Triassic period was published, the following discoveries, all of which tended to enlarge the Triassic lake areas, have been made:—

1. The nature of the Bellevue fossils examined by Walkom,[11] together with the field work of Reid and Morton,[12] has resulted in the Esk series, which had previously been assigned tentatively by Walkom to the Walloon (Jurassic) series, being correlated with the Ipswich (Triassic) series.
2. The work of Bryan and Massey[13] has shown that the so-called "Tiaro series," formerly regarded as the equivalent of the Walloon series, was in reality made up of three conformable series, the lowest of which could be correlated satisfactorily with the Ipswich series.
3. The discovery by Jensen[14] of an extensive series of deposits equivalent to the Ipswich series to the north of Roma.
4. The correlation of certain areas of massive sandstone, which occur overlying the Bowen River coalfield and its southerly prolongation, with the Bundamba series, by Reid.[15]



Text-figure 1.

Although the barren Bundamba series has not yielded sufficient fossils for the precise determination of its age, the authors have followed Walkom[16] in treating it with the underlying Ipswich series rather than with the overlying Walloon series. Thus, while the numbers 1 to 5 in the accompanying map represent localities in which the Ipswich series (or one of its equivalents) is found, localities 6 to 9 represent massive sandstones of Bundamba type. The authors are indebted to officers of the Geological Survey of Queensland for information as to the position and extent of these sandstones.

Although the Triassic lacustrine area, as now mapped, shows a very great enlargement in comparison with the maps of earlier workers, the authors feel that this extension is conservative; for the works of Ball and of Jensen in the Cape York Peninsula suggest that a considerable portion of this area may also have been covered by Triassic lakes.

An interesting feature about the map is that a natural prolongation of the Triassic lake southerly from Queensland would just enclose the area of New South Wales covered by members of the Clarence series. There has been some controversy[17] as to whether the Ipswich and Bundamba series are represented in the Clarence series, and the present map certainly suggests (though it does not prove) that the Clarence area was covered by a lake in Triassic times.

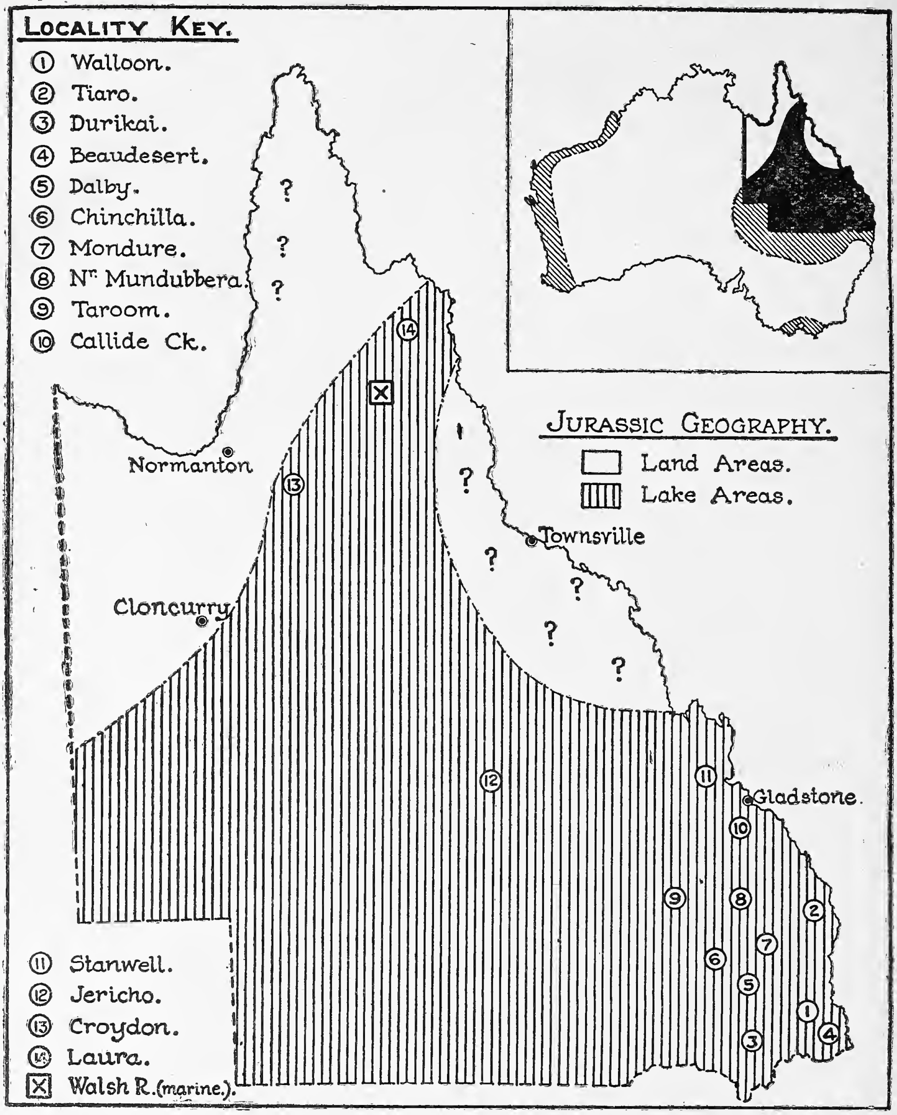
III. JURASSIC PALÆOGEOGRAPHY.

The accompanying map of Queensland in Jurassic times is very like those of Walkom and of Benson, except in the far north. As a result of the field work of Morton[18] a large area in the western half of the Cape York Peninsula which previously had been tentatively regarded as of Jurassic age may now be most reasonably assigned to the Cretaceous period, and consequently is so treated in this series of maps.

The huge extent of the Jurassic lake, the abundance of plant remains, and the absence of salt and gypsum deposits, all indicate uninterrupted drainage and suggest a free outlet to the sea. From the distribution of the Walloon series, Walkom came to the conclusion that the most probable outlet lay in northernmost Queensland. However, as a result of Morton's work[19] the probability of an outlet in this direction is considerably diminished.

Although the map now submitted does not show this feature, there is evidence that during the Jurassic period, and indeed within the limits of time represented by the Walloon series, true marine conditions were present in certain areas for restricted times.

Among the fossils collected in North Queensland by the Hann expedition and now lodged in the Queensland Museum, is a large *Coroniceras* (*C.* aff. *bucklandi* J. Sowerby sp.) recorded from the Walsh River, which flows completely across the Mesozoic outcrops. This would indicate localised marine conditions in the Lower Lias (Coroniceratan stage). Such a phase may have been purely transient, as in Western Australia, where the marine beds of the Jurassic represent merely the *sauzei* and *Emileia* zones of the Bajocian.[20] Similar localised phases of the marine Jurassic (Bajocian and Bathonian) were characteristic also of New Guinea. Consequently one may expect to find, in the future, marine beds of limited thickness interbedded in the Walloons at other localities in Eastern Queensland (see later reference to the Cretaceous Morven bed).



Text-figure 2.

In the several papers dealing with the Jurassic palæogeography of Queensland, mention is often made of a supposed deep inlet which Neumayr named the "Queensland Gulf."[21] Walkom[22] has pointed out that the only positive evidence in favour of the existence of this gulf is "the presence of an impoverished fauna of Foraminifera and Ostracoda in the upper beds of the Wianamatta stage in New South Wales." In spite of its name there is no fossil evidence forthcoming from Queensland itself confirming Neumayr's supposition. Notwithstanding the absence of direct evidence in its favour, the presence of such an inlet in Jurassic times would supply a plausible link, both spatially and temporally, between the great and persistent Tasman geosyncline of Palæozoic times and the present important Thompson trough.

A temporary marine phase in the Walsh River area might well be explained by an epicontinental transgression from such a gulf, or from another possible arm of the sea, extending through the present Torres Strait, which, in the Bathonian, gave an offshoot to the north, resulting in the deposition of marine beds in the Fly and Strickland Rivers region.

Again, if there were an outlet of the Walloon lake to the sea in the north-easterly direction, as suggested on the accompanying map, a marine phase in the Walsh River area may be explained by a fluctuation in this connecting arm.

The Walloon series of Southern Queensland is characterised in many areas by a calcareous phase, which Jensen[23] suggests is typical of the lower portion of the series.[24] Abundant cone-in-cone structure is developed in these beds; and, from the extreme rarity of this feature in beds other than of marine origin in other parts of the world, it may be thought that this also is evidence of localised marine conditions. However, all the available evidence at the moment tends to the idea that these are lacustrine limestones.

Deposition within the lake or series of lakes which gave rise to the Walloon series may not have been continuous or have represented the same time interval in various regions. In the Walsh River area, according to what information is available, there does not seem to be a great thickness of Walloon beds beneath the Roma series (Cretaceous). Consequently, considering the evidence of the *Coroniceras,* it may be that the lower Cretaceous shales in this area rest directly upon Lower Lias beds or beds of a little later date. Should this be so, discontinuous deposition is not necessarily indicated, for overlap, or pene-contemporaneous erosion, may have been involved.

IV. CRETACEOUS PALÆOGEOGRAPHY.

The Cretaceous in Australia was a period of alternating marine and non-marine conditions. The large central depression, occupied in the Jurassic by the Walloon lake, persisted, and, as mentioned later, it is most probable that the lacustrine conditions of the Walloon continued within the Neocomian.

The earliest marine stage known in the Australian Cretaceous is that of the Morven bed, which represents the Simbirskitan stage of the Hauterivian. This determination, made by Whitehouse[25] on the evidence of a *Simbirskites,* has since been supported by the same author's record[26] of fossils from the succeeding marine horizon at the same locality (Victoria Downs, Morven) and by the field work of L. C. Ball.[27] This may have been but a transient marine condition similar to the Lower Lias of the Walsh River, for at present it is known only from the one locality.

Two main transgressions of the sea took place over the area. The earlier and, apparently, the more extensive of these began in the Lower Bedoulian (lowest Aptian), as shown by the work of one of us

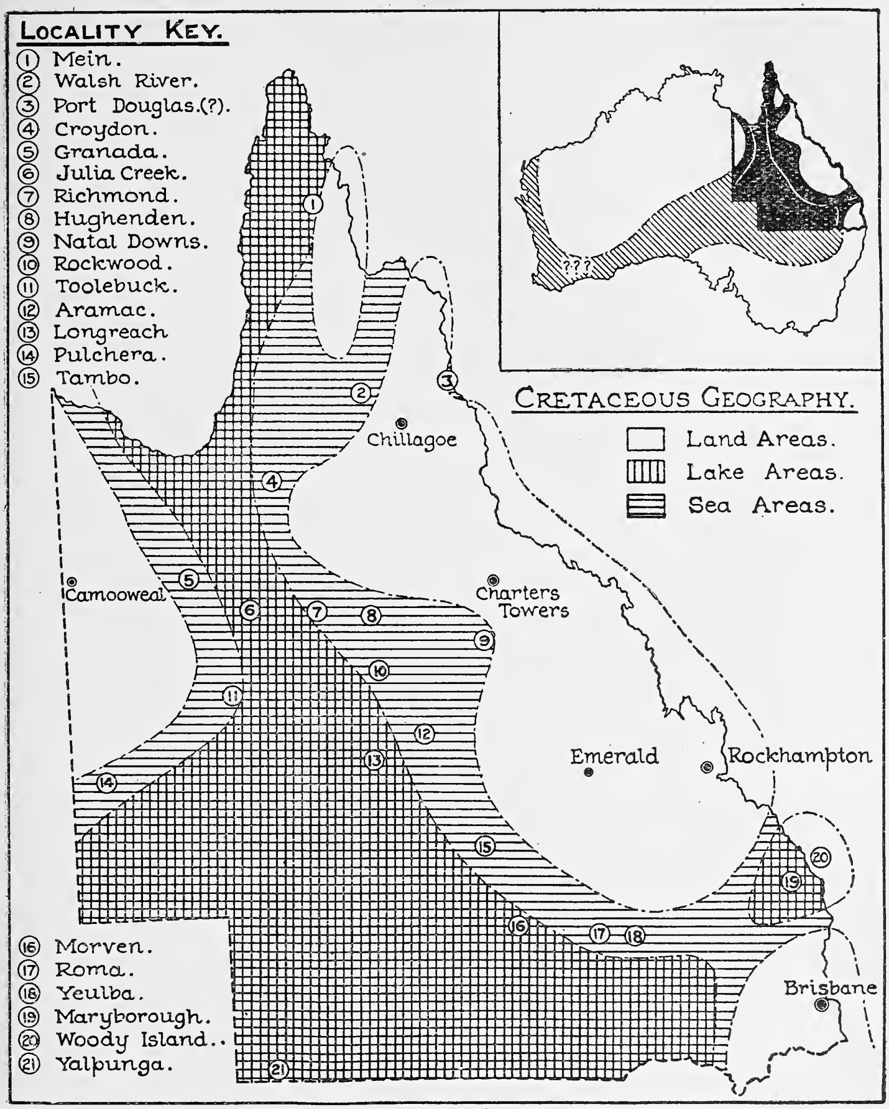
(F.W.W.)[28] on the cephalopods. This transgression, which gave rise to the beds of the Roma series, was caused, apparently, by the flooding of the Walloon lake by the sea. Consequently it is probable that the upper time limit of the Walloon series should be drawn at the top of the Neocomian (Barremian). The abundant individuals of genera suggesting a brackish condition (*Cyrenopsis,* etc.) in the basal beds of the Roma series lends support to the idea that the sea invaded a lake rather than the basin from which the lake waters had previously withdrawn.

The outcrop of the "Rolling Downs formation," as marked on the Queensland geological maps, gives the areal distribution of the Roma series, except in the north-west, where (*v. inf.*) the Tambo series completely overlaps on to beds of Pre-Cretaceous age. It may be noted that those areas on the margin of the basin (Croydon and White Cliffs), which have been mapped as "Desert Sandstone," represent the base of the Roma series. The evidence for this is to be published very shortly by one of us (F.W.W.).

Following the close of the Roma series at the top of the Aptian (Upper Gargasian), there was a non-sequence due to a regression of the sea from the whole area. The succeeding beds, forming the Tambo series, represent the Upper Albian. No Lower or Middle Albian fossils are known in the area, and there is no evidence from the bore records to suggest that any deposition took place in the time interval separating the two series. It may be that in the centre of the Great Artesian Basin, where bores are very few, beds of limited horizontal distribution deposited in this interim may be present (at a considerable depth); but, in the absence of evidence to the contrary, we may reasonably assume that the regression of the sea from the area was complete at the end of the Roma series.

With the incoming of the Tambo sea there were, naturally, conditions of overlap. At all the recorded fossiliferous localities of the western margin of the basin, from the latitude of Oodnadatta (South Australia) northwards, only the Tambo series is represented. It is apparent, therefore, that in this area the overlap of the Tambo series over the Roma series on to older beds was complete. On the eastern and southern margins of the basin, overlap of the Tambo series on to earlier portions of the Roma series has happened at various localities, the evidence for which will be published at a later date by one of us (F.W.W.).

The outlets of this central sea may now be considered. Of the three previous palæogeographic maps of the region published locally,[29 30 31] all agree in having an outlet to the north. Walkom and Benson, further, indicate an outlet to the south-west via the Eucla basin. This is not shown on Jensen's map. Jensen and Benson treat the Maryborough marine beds as an extension from the main basin, but no outlet to the sea is suggested in this region. On Walkom's map the Maryborough beds are treated as a separate arm of the sea, not connected directly with the central basin.



Text-figure 3.

In the present map the obvious outlet to the north is upheld. That there was an east-west gulf in the region of the present Arafura Sea during the Jurassic appears certain. Such a sea was present during the Cretaceous, accounting for the transient deposition of Upper Albian beds (slightly later in age than the Tambo series) at Point Charles, and of the Lower Cenomanian (*baylei* zone) beds of Melville Island. It may be mentioned that beds with Cenomanian fossils (to be described shortly by one of us) very similar to those of Melville Island, occur at the Strickland River in New Guinea. It seems, therefore, that the northern extension of the basin is connected with this gulf.

Further, an outlet to the south, via the Eucla basin, is also maintained. The Cretaceous fossils reported from the latter locality include *Fissilunula* (?) *sp., Maccoyella corbiensis* (Moore), and *Aucellina hughendenensis* (Eth.).[32]

This list, if the identifications are correct, includes species of both the Roma and Tambo series, and points to an outlet to the south during both periods. It is probable that the connecting strata from the area between the Eucla and the main basins have been removed by erosion, following uplift.

A third outlet is suggested in the Maryborough region. The fossils of this area agree so well with those of the Lower Roma series of the main basin that there can be little doubt that the Maryborough basin was continuous with the main basin. The percentage of brackish water types in this area is much lower than of other areas (e.g., White Cliffs) of the same horizon[33] (Lower Roma series). Consequently it is assumed that there was an outlet to the ocean in this direction.

That the sea connection between the Maryborough and Western area was, however, only of a transitory nature is indicated by the fact that only the lowest portion of the Roma series is represented in the Maryborough beds.

Again, it may be noticed that a specimen of the Tambo series species *Myloceras Ammonoides* (Eth. fil.) is recorded from Port Douglas. As Etheridge[34] has suggested, the locality may be incorrectly given; but, if it be correct, it supports the suggestion held by one of us (F.W.W.) that in the Cretaceous, the *essential* outline of Australia did not differ very considerably from its present form.

At the close of the period of the Tambo series the sea withdrew, and no later beds definitely of marine origin are known in Queensland during the Cretaceous, although they existed in other States (Santonian at Gingin, Western Australia; Cenomanian at Melville Island).

The Post-Tambo series beds in the Great Artesian Basin were included by Dunstan[35] as the Winton series, the name "Desert Sandstone" being restricted to deposits originating secondarily from beds ranging from Jurassic to Tertiary. Ward and Jack,[36] however, recognise two stages above the "Rolling Downs." The lower of these, the "lignitic series" of these authors, would correspond with the Winton series of Dunstan, and is of lacustrine origin. This would indicate that the depression occupied by the Tambo sea remained when marine conditions ceased, and became the site of an extensive lake or series of lakes.

Ward and Jack retain the name "Desert Sandstone" for a succeeding series, which, according to them, contains marine fossils. One of us (F.W.W.) has examined the marine cretaceous fossils now in the various

Australian museums, but has seen no forms which would indicate an horizon higher than the Tambo series.

Further, such localities as Croydon and Maryborough (in Queensland), White Cliffs (New South Wales), and Stuart Range (South Australia), which, from their lithology, have been recorded as localities for the marine stage of the "Desert Sandstone," all yield faunas typical of the lower portion of the Roma series. It seems to us therefore that the so-called marine stage of the "Desert Sandstone" is nothing other than superficially altered sediments of the Roma or Tambo series; and that, if a distinct series is to be recognised overlying the Winton series, it also is most probably of lacustrine origin.

That portion of such lacustrine series should be shown on the Tertiary map is very probable; but in the absence of definite evidence to the contrary these sediments are treated in this essay as Cretaceous. It should be mentioned that the highest fossils obtained in the very deep Patchewarra bore were at 4,500 ft.; and these, examined by one of us (F.W.W.), were typical Tambo series forms (*Labeceras trifidum* Whitehouse, *Hamites* sp.). This indicates a minimum thickness of about 4,000 ft. for these Post-Tambo beds.

From Plutoville, in Cape York Peninsula, Mr. Morton[37] recently obtained fossil plants from beds apparently underlying the Roma series. These plants were determined by Dr. Walkom as of lower Cretaceous age. This would agree with the idea advanced earlier in this paper that the top of the Walloon series transgresses into the Cretaceous. No Jurassic fossils are known in this area, which rather suggests that the Walloon lake extended northwards rather late in its history.

The stratigraphical position of the known Marine Cretaceous deposits of Australia may be tabulated thus:*

	Danian	
Senonian	Maestrictian	
	Campanian	
	Santonian	Gingin Chalk (W.A.).
	Coniacian	
	Turonian	
	Cenomanian	Melville Island bed.
	Albian ..	Tambo series; Point Charles Bed; Cardabia bed (W.A.); Eucla beds (*pars.*).
	Aptian ..	Roma series and Maryborough beds; ? Eucla beds (*pars.*).
Neocomian	Barremian	
	Hauterivian	Morven bed.
	Valanginian	
	Infra-Valanginian.	

* This table is based on the work of one of us (F.W.W.), much of which is still unpublished.

V. TERTIARY PALÆOGEOGRAPHY.

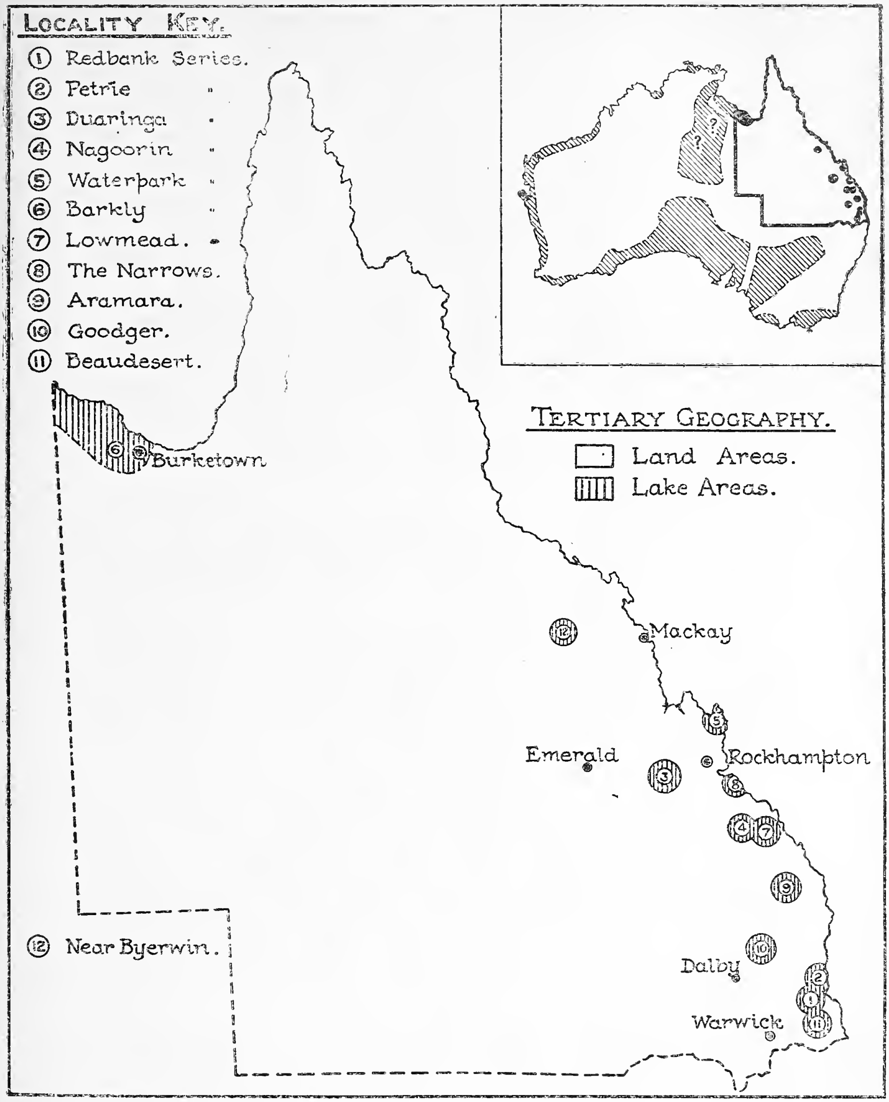
Although very little work has been done in Queensland with the object of obtaining a full knowledge of the extent and nature of the Tertiary deposits of the State,* incidental references to strata of this age are to be found in many of the publications of the Geological Survey of Queensland. Such references are so comparatively numerous as to suggest that the Tertiary deposits of the State are much more widespread than is generally supposed.

As little is yet known of the extent of the Tertiary deposits, the area of each has been represented conventionally by a circle in the accompanying map. Of the occurrences shown, one is based upon information hitherto unpublished—namely, the finding of a fossil flower of modern aspect at Goodger, near Kilkivan.

Although each locality upon the map is represented as an isolated lake, further work may well prove that some of these areas were once connected. It would not be reasonable, however, to expect very much progress in this direction, for the areal discontinuity of the deposits is not the only obstacle to be overcome. Proof of contemporaneity of any two deposits may be much more difficult, and without such proof it would be positively dangerous to assume that they were deposited simultaneously, for there is no reason whatever for regarding all the Tertiary deposits of Queensland as representative of the one horizon. On the contrary, they probably are the result of several distinct periods of deposition. The importance of this aspect needs to be emphasised, as there exists in Queensland the tendency to under-estimate the length of the Kainozoic era—to regard it, indeed, as merely a period, and a short one at that. Hence it would serve no useful purpose to draw *one* map of Queensland for the whole Kainozoic era, as many important geographical changes quite probably took place within the era itself. However, the nature and distribution of our Tertiary deposits provide us with suggestions which, while they are regarded merely as such, are not without some value.

The fact that all are lacustrine suggests that the whole of Queensland was a land area during the Tertiary, while the restriction of the Tertiary deposits to the neighbourhood of the present coast seems to indicate shore lines not far from the present one. The latter suggestion is supported by the fact that several of the occurrences contain fossil ostracods, which are indicative of estuarine or brackish water conditions.

* A notable exception is the valuable paper by Mr. O. A. Jones, B.Sc., entitled "The Tertiary Deposits of the Moreton District," which was recently read before this Society.



Text-figure 4.

The great differences in the lithological nature, fossil content, and tectonic history of the Tertiary deposits of the island of New Caledonia, when compared with those of Queensland, point to their structural independence during Kainozoic times, and suggest that the Queensland coastlines lay far to the west of New Caledonia, a suggestion which is in harmony with the tentative conclusions arrived at above.

That the landmass of Northern Queensland was connected with that of New Guinea during Kainozoic times there can be little doubt, but whether such connection was continuous throughout the era cannot at present be decided, nor can the exact date of its final partition.

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22. Op cit. (16), p. 103.
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New Queensland Acacias.

By

(The late) J. H. Maiden*, I.S.O., F.R.S., F.L.S., late Government Botanist of New South Wales, and Director of the Botanic Gardens, Sydney,

and

W. F. Blakely, Assistant Botanist, National Herbarium, Sydney.

Plates XVI—XIX.)

(*Communicated by C. T. White before the Royal Society of Queensland, 30th August*, 1926.)

UNINERVES—RACEMOSÆ.

1. *Acacia angusta*, n. sp.

(Plate XVI., figs. 1-6.)

Frutex gracilis Mallee similis, ramis pendulis rubidis; ramulis teretibus vel plus minus angularibus, partibus junioribus paulo pruinosa-tomentosis, phyllodiis linearibus tenuibus rectis uninerviis 10-20 cm. longis 2 mm. latis; glandulis duabus marginalibus; racemis axillaribus simplicibus paulo tomentosis circiter 1″ longis; floribus glabris 12-20 in capitulo, plerumque 5-meris; sepalis lineari-spathulatis corollam dimidio aequantibus; petalis latis laevibus liberis uninerviis; ovario hirsuto; legumine non viso.

A tall, glabrous, weak-growing, Mallee-like shrub, with slender stems not more than one inch in diameter, and somewhat pendulous branches. Branchlets reddish, terete to somewhat angular, the very young tips slightly hoary-tomentose. Phyllodia linear, thin and straight, terminating in a fine point, uninerved, 10-20 cm. long, 2 mm. broad, usually with a large gland near the base, and a smaller one about the centre of the phyllode. Racemes axillary, simple, slightly tomentose, about one inch long. Flowers glabrous, 12-20 in the head, pale-coloured, mostly 5-merous. Sepals linear, spathulate, half as long as the corolla. Petals broad, smooth, free, uninerved. Ovary hirsute. Pod not seen.

Range.—The Virgin, Springsure, Queensland, *J. L. Boorman*, 3rd August, 1913. The type.

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* As is well known, the late Mr. J. H. Maiden was the leading authority on the two large Australian genera *Eucalyptus* and *Acacia*. During the last years of his life he received considerable help in this work from Mr. W. F. Blakely, and the present Paper is one of a series that Mr. Maiden and Mr. Blakely were preparing in collaboration shortly before the former's death. The Paper consists of descriptions of seven new species and one new variety, mostly received by Mr. Maiden from Queensland correspondents.—C. T. White.

Affinities.—1. With *A. neriifolia* A. Cunn., especially the very narrow form. The phyllodes, however, are uniformly narrower, more glabrous and different in shape. The inflorescence is also much shorter, while the flowers are smaller and paler and fewer in the head.

2. With *A. Dietrichiana* F.v.M. The phyllodes of both species are very similar, but there appears to be only one marginal gland on the phyllodes of *A. Dietrichiana,* while the branches are viscid, and the inflorescence consists mainly of single heads, not definitely racemose as in *A. angusta.*

2. *A. semirigida,* n. sp.

(Plate XVI., figs. 7-14.)

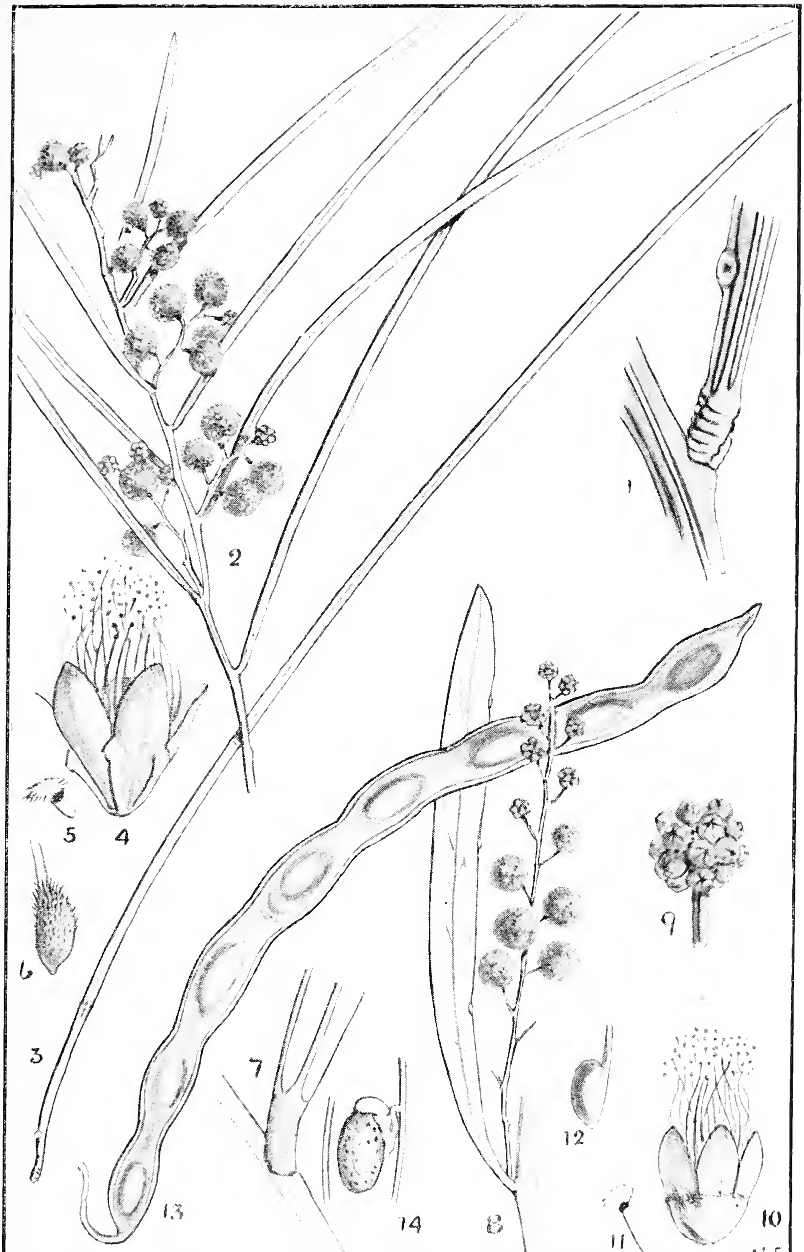
Frutex altus glaber; ramulis acute angularibus; phyllodiis rigidis angusto-lanceolatis acutis 4-9 cm. longis, 4-8 mm. latis, nervis marginalibus prominentibus, superiore glandulas 1-3 prominulas gerente, costa plerumque margini superiori propiore; racemis axillaribus glabris phyllodiis brevioribus, capitula 10-20 pallidissima ca. 20 florum 5 merorum gerentibus; calyce cupulari sinuolato plus minus ciliato; petalis liberis paulo hirsutis; ovario glabro; legumine stipitato plerumque recto; valvis tenuibus inter semina attenuatis 8-12 cm. longis, 10-12 mm. latis; seminibus oblongis minutis punctis notatis rugosis; funiculo filiformi in arillum clavatum dilatato.

A tall, glabrous shrub; branchlets acutely angular. Phyllodia rigid, narrow-lanceolate, acute, minutely punctate, uninerved, 4-9 cm. long, 4-8 mm. broad, narrowed at the base, with prominent marginal nerves, and obscure lateral veins, the upper margin bearing 1-3 fairly prominent glands, the lower gland usually about 2 cm. from the base; midrib not quite central, usually closer to the upper margin. Racemes glabrous, axillary, shorter than the phyllodia, 3-6 cm. long, bearing 10-20 very pale flower-heads of about 20, mostly 5-merous, flowers; peduncles compressed to slightly angular, 5-8 mm. long. Bracts capitate, ciliate. Calyx cupular, sinuolate, the border more or less ciliate. Petals free, slightly hirsute, longer than the calyx. Ovary glabrous. Pod stipitate, straight or curved, pale brown and shining, valves thin, contracted between the seeds, the margins nerve-like, up to 12 cm. long, 10-12 mm. broad. Seeds placed longitudinally, oblong, black, minutely pitted rugose, the funicle filiform for more than half its length, with one fold about the centre of the seed, the basal portion dilated into a short, thick, club-shaped aril over the end of the seed.

Range.—In a gully near Dairy Mountain, Eidsvold, Queensland, *Dr. T. L. Bancroft,* No. 24. The type. Stannary Hills, *Dr. T. L. Bancroft,* per C. T. White.

Affinities.—1. With *A. adunca* A. Cunn., from which it is distinguished by its broader phyllodes, more numerous glands, which are also of a different shape, paler flowers, broader pods and differently marked seeds.

2. With *A. neriifolia* A. Cunn., which is perhaps its closest affinity, and from which it may be distinguished by being strictly glabrous, having fewer and paler flowers, different shaped calyx, and pitted seeds.



Acacia angusta n. sp., 1-6.

Acacia semirigida n. sp., 7-14.

[*Face page* 116.]

3. *A. pustula*, n. sp.

(Plate XVII., figs. 8-12.)

Arbor parva glabra 30-40′ alta; ramulis angularibus; phyllodiis uninerviis angustis oblongis falcatis vel angusto-lanceolatis, 7-12 cm. longis, 4-7 mm. latis, tenuibus non rigidis, venis lateralibus paulo penninerviis; costa utrinque prominente; glandula vix centrali, magna orificio magno; racemis phyllodiis brevioribus; floribus 5-meris; calyce paulo cupulare, lobis obtusis, ciliatis; petalis latis, lanceolatis paulo hirsutis; ovario glabro; legumine non viso.

A small, glabrous tree, 30-40 feet high, up to 12 inches in diameter. Bipinnate leaves from reversion shoots (suckers) numerous. Pinnae in three pairs, 3-4 cm. long, usually with a large gland opposite each pair, but sometimes wanting in the upper pairs. Leaflets 3 to 8 pairs, glabrous, pale green on both sides, oblong to slightly oblique, the lower leaflets 1-2 nerved, the upper ones sometimes triplinerved, with a gland opposite each pair, the main nerve closer to the upper margin, 5-12 mm. long, 2-4 mm. broad. Intermediate phyllodia from reversion shoots (suckers) evolved from the last pinnae, broad-lanceolate, penninerved, tapering into the petiole, the midrib nearer the lower margin, the upper margin bearing two, but usually one, conspicuous pimple-like gland on the lower half, 5-10 cm. long, 1-2 cm. broad. Adult phyllodia uninerved, narrow oblong to narrow-lanceolate, 7-12 cm. long, 4-7 mm. broad, thin, not rigid, the lateral veins more or less penninerved, the marginal nerves scarcely conspicuous, midrib prominent on both sides, gland towards the middle, rather large, pimple-like, with a large orifice. Racemes shorter than the phyllodia with 10-20 globular heads of 18-25, mostly 5-merous, flowers. Calyx somewhat cupular, with obtusely, slightly thickened, ciliate lobes. Petals broad, lanceolate, slightly hairy, longer than the calyx. Ovary smooth. Pod not seen. So named from the prominent marginal gland.

Range.—Eidsvold, Queensland, *Dr. T. L. Bancroft*, Nos. 13, 22, March to August, 1918. Brian's Pastures, Gayndah, *S. A. Lindeman*, July 1903.

Affinity.—With *A. neriifolia* A. Cunn., with which it has been confused, but *A. pustula* is strictly glabrous in all its characters, with the exception of the petals, whereas the phyllodes and inflorescence of *A. neriifolia* are silky pubescent. Although the phyllodes of both species are somewhat alike, they can be distinguished from each other by the absence of the large basal gland in *A. pustula*.

4. *A. attenuata*, n. sp.

(Plate XVII., figs. 1-7.)

Frutex parvus glaber, ramis angularibus et foliis heteromorphis; phyllodiis uninerviis rigide coriaceis oblongis vel fere spathulatis obtusis 6-13 cm. longis, 8-20 mm. latis in petiolum elongatum attenuatum; glandula basin versus; racemis axillaribus phyllodia aliquando superantibus; floribus 5-meris; calyce breviter lobato apice dense ciliato; petalis liberis glabris calycem duplo superantibus; ovario glabro; legumine immaturo plano ad 10 cm. longo, 1-1.5 cm. lato, inter semina paulo attenuato.

A small, glabrous shrub with angular branches and strongly heteromorphic leaves, the bipinnate foliage borne on the adult euphyllodineous plants, and even on the flowering branches. Bipinnate leaves, pinnae in 2-3 pairs, 4-8 cm. long; petiole compressed to semi-terete below the first pair of pinnae, with a linear gland a short distance from the base, the rachis deeply channelled on the upper surface, convex beneath; glands obscure or none; terminal seta small, acute. Leaflets 5-16 pairs, glabrous, very shortly petiolate, oblong to somewhat oblique, mucronulate; imperfectly and obscurely bi- or triplinerved; terminal seta of each pair of pinnae acute and somewhat gland-like. Phyllodia uninerved, rigidly coriaceous, oblong to almost spathulate, obtuse, or with a very small, curved mucro, 6-13 cm. long, 8-20 mm. broad in the middle, much narrowed into the somewhat elongated petiole, with a small marginal gland close to the base, the midrib confluent with the lower margin, the nerve-like margins and midrib conspicuous, lateral veins obscurely penninerved. Racemes axillary, glabrous, sometimes exceeding the phyllodia, with 4-12 rather large, globular heads on long peduncles, of about 20 5-merous flowers. Calyx divided nearly to the middle into five thick, linear, densely ciliate lobes, which probably separate to the base on maturity. Petals free, glabrous, thick, lanceolate, more than twice the length of the calyx. Ovary glabrous. Pod not seen in a fully ripe state, flat, up to 10 cm. long, 1-1.5 cm. broad; slightly contracted between the longitudinal seeds, valves thin; funicle filiform with one fold exceeding the seed.

Range.—Beerwah, 47 miles north of Brisbane, near Glasshouse Mountain, *C. T. White*, No. 1816, September, 1922.

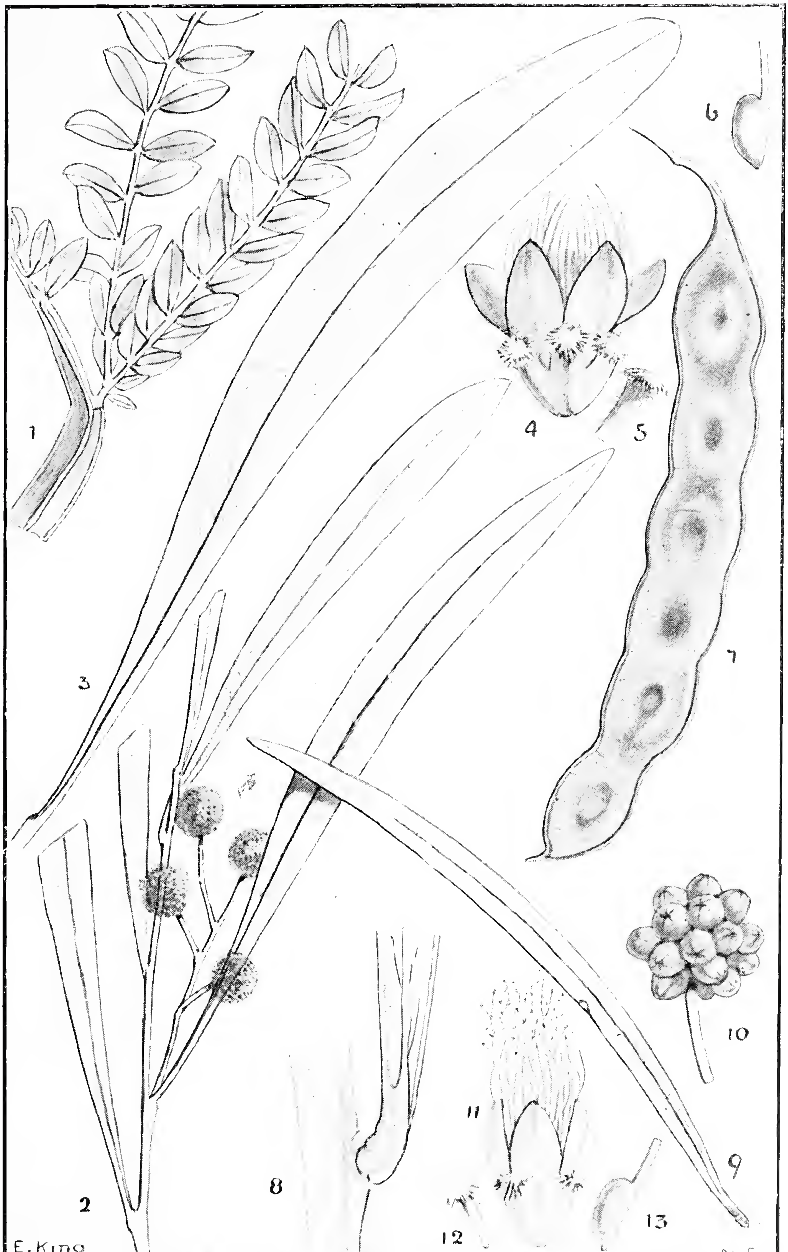
Affinity.—With *A. rubida* A. Cunn., with which it bears a very strong resemblance in its heteromorphic leaves, but differs mainly from that species in the more attenuated phyllodes, with the relatively smaller, different-shaped and strictly basal gland; in the large flowers, different shaped calyx, glabrous petals and much broader pod.

5. *A. semilunata*, n. sp.

(Plate XVIII., figs. 1-10.)

Frutex compactus 6-12′ altus, ramulis semi-teretibus breviter pilosis; phyllodiis angusto-oblongis ad semi-lunatis mucronulatis 1.5-2.5 cm. longis, 4-7 mm. latis; petiolo brevi piloso; glandula parva infra medium phyllodii; racemis axillaribus terminalibus glabris 4-8 cm. longis; floribus sulphureis 5-meris; calyce cupulari sinuolato ciliato petalis breviore; petalis liberis laevibus; ovario glabro; legumine lineari contracto 5-8 cm. longo, 4-5 mm. lato; seminibus longitudinalibus oblongis nitentibus nigris.

A compact shrub, 6-12 feet high, with terete, reddish, branches, which are loosely invested with short white hairs, otherwise glabrous and echinate with the remains of the rudimentary common peduncles. Phyllodia narrow-oblong, mucronulate to semi-lunate, 1·5-2·5 cm. long, 4-7 mm. broad, the lower margin straight or nearly so, the upper arcuate, usually with a small depressed gland on the lower half; midrib central



Acacia attenuata n. sp., 1-7.

Acacia pustula n. sp., 8-12.

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or nearly so, continuous to the base; petiole small, distinct, usually pilose, also the base of the phyllode. Racemes axillary and terminal, usually simple, 4-8 cm. long, bearing 12-30 globular heads of 10-15 bright-yellow, 5-merous, glabrous flowers. Calyx patelliform, glabrous, except the sinuolate ciliate border. Petals free, smooth and broad, slightly keeled, more than three times the length of the calyx. Bracts capitate, ciliate. Ovary glabrous. Pod glabrous, shortly stipitate, linear, convex, straight or curved, contracted between the seeds, 5-8 cm. long, 4-5 mm. broad. Seeds longitudinal, oblong, glossy black. Funicle thread-like for about half its length, with one short central fold, then gradually thickened into a club-shaped lateral aril over the end of the seed.

Range.—Knockbreak Station, *viâ* Chinchilla, Queensland, *Dr. T. L. Bancroft*, August, 1918. The type. Auburn River, between Taroom and Eidsvold, *Dr. H. I. Jensen*, August, 1922, per C. T. White. Texas, *J. L. Boorman*, September, 1910.

Affinity.—With *A. cultriformis* A. Cunn. There is a general similarity between the two species as regards the phyllodes, which are, however, more lunate and uniformly broad in *A. semilunata*, less glaucous, or not at all glaucous, while the branchlets of the latter are pilose and more terete than the branches of *A. cultriformis*. There are also certain morphological differences in the flowers of both species.

6. *A. jucunda*, n. sp.

(Plate XVIII., figs. 11-16.)

Frutex robustus 8-15′ altus, surculis pruinosis, ramulis breviter pilosis; phyllodiis tenuibus obscuris oblongis vel angusto-lanceolatis plerumque mucronatis uninerviis fere glabris 4-6 cm. longis, 1·5-2·5 cm. latis; glandula marginali prope basin; racemis axillaribus glabris 3-9 cm. longis, capitula 10-30 globosa 15-20 florum 5-merorum gerentibus; calyce turbinato, lobis brevibus crassis ciliatis; petalis laevibus calyce multo longioribus; ovario glabro; legumine non viso.

A robust shrub, 8-15 feet high, the young tips hoary with a very short, soft, tomentum; branchlets slightly angular, and more or less invested with short, white hairs. Phyllodia thin, dull, oblong to narrow-lanceolate, mucronate, uninerved, glabrous or nearly so, 4-6 cm. long, 1·5-2 cm. broad, the margins nerve-like, scarcely prominent, midrib raised on both sides, scarcely central, usually closer to the upper margin; lateral veins very fine, penninerved; gland small, close to the base. Racemes axillary, rarely terminal, glabrous, 3-9 cm. long, bearing 10 to over 30 small, globular heads of 15-20, 5-merous flowers; peduncles short, slender, subtended by a small, acute bract. Bracts of the flowers capitate, ciliate. Calyx cupular to turbinate, faintly ribbed, almost truncate, with a ciliate border. Petals 5, free, glabrous, lanceolate, more than twice the length of the calyx. Ovary glabrous; pod not seen.

Range.—Knockbreak Station, *viâ* Chinchilla, Queensland, *Dr. T. L. Bancroft*, Nos. 25, 35, August, 1918, also at Lochaber Station, same district and collector.

It is one of those species which does not appear to set pods, as observed by Dr. Bancroft in his letter to me (J.H.M.) dated 13th November, 1923, as follows:—

"You will remember my number 25 Acacia, a form somewhat resembling *A. podalyriæfolia*, which you pronounced new, but could not name until you saw the pods. There was a scrub of it at Lochabar. Afterwards I found it at Knockbreak, and Mr. Sinclair promised to get pods. I want to tell you that this Acacia does not seem to make fruit; it seems to be a free suckering form. At Lochabar, where there is half an acre of a scrub of it, I marked with white rags several places where there were flowers. Afterwards I visited the place and saw the branches I had marked, but there were no pods. I think this was four years ago; at that time I dug up several small suckers and managed to strike one of them in sand and afterwards planted it in the garden; it has produced a beautiful bush and recently was loaded with flowers. It produced more flowers than those both at Lochaber and Knockbreak (both places visited by me recently). I should say it is worthy of cultivation, as the foliage is pretty and the flowers exceptionally beautiful. I watched my plant carefully for pods, but none were formed.

''At Knockback recently I marked several branches where there appeared indications that fruit was forming, but I have learned from Mr. Sinclair that pods were not formed. Now can you tell me whether it is likely that this Acacia will ever form fruit? Don't you think you could name it without seeing the pods? At Lochaber the plants there were very dry when I looked recently for indications of pods forming. The dry season (one might say) was the reason of the plant not forming seed. My bush, however, was in a good place and was watered; there were several indications that a pod was likely to form, but the raceme withered away. In the parcel of specimens I am sending the good ones are from my bush; the others, some from Lochaber and some from Knockbreak. It is a pity, after all these years of waiting and watching, that no pods can be obtained.''

Affinity.—With *A. podalyriæfolia* A. Cunn., from which it may be distinguished by being more glabrous and greener, by the narrower and longer phyllodes and basal gland, and in the glabrous racemes, smaller and glabrous flowers, and also in habit.

JULIFLORAE-RIGIDULAE.

A. stipuligera F.v.M., var. glabrifolia, n. var.

Young tips resinous, strictly glabrous, phyllodes glabrous, usually binerved. Jericho, Queensland, H. Deane, No. 212.

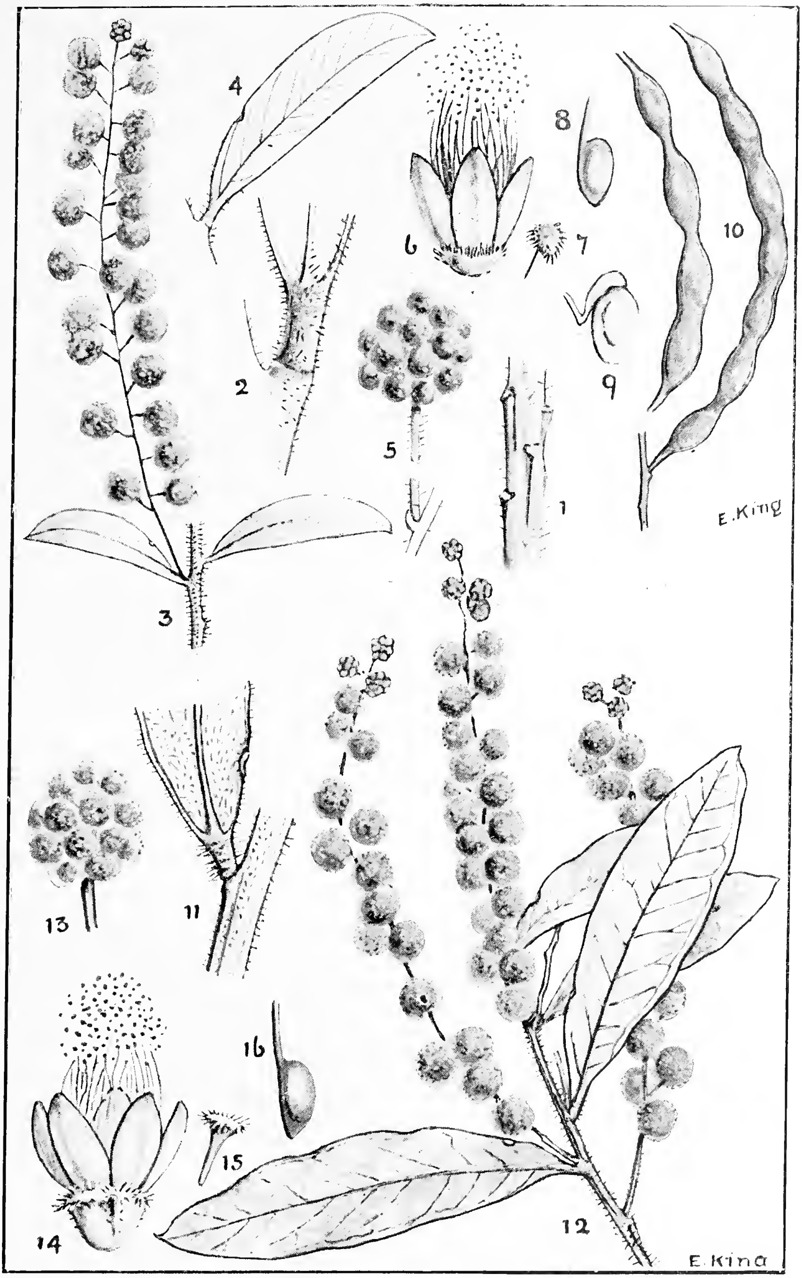
BIPINNATAE-BOTRYOCEPHALAE.

7. *A. glaucocarpa*, n. sp. (A. polybotrya Benth. var. foliolosa Benth.). (Plate XIX.)

The variety name *foliolosa* cannot be taken up as it is preoccupied by *Acacia foliolosa* R. Grah., which equals *Albizzia myriophylla.*

Frutex altus vel arbor parva plus minus glaucus et pubescens; ramulis teretibus; pinnis 3-7 paribus 2-4″ longis; foliolis 12-25 paribus oblongis obtusis vel acutis; 5-14 mm. longis, 2-3 mm. latis; floribus in racemis axillaribus vel terminalibus, 15-20 in capitulo, 5-meris; pedunculis brevibus crassis tomentosis; calyce pruinoso lato-turbinato; sepalis brevibus dense ciliatis; petalis glabris liberis tenuibus uninerviis; ovario pruinoso; leguminibus glaucis 8-13 cm. longis, 1 cm. latis plerumque rectis inter semina contractis; seminibus ovatis 5-6 mm. longis, 3-4 mm. latis; funiculo crasso naviculari seminis apicem tegente.

A tall shrub or tree, more or less glaucous and minutely pubescent; branchlets terete and somewhat distantly striate. Pinnae 3-7 pairs or



Acacia semilunata n. sp., 1-10.

Acacia jucunda n. sp., 11-16.

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more, 2-4 inches long, leaflets 12-25 pairs, oblong obtuse or very shortly acute, 5-14 mm. long, 2-3 mm. broad, the midrib nearer the upper margin, and sometimes there are 1-2 very fine spreading nerves on the lower portion, which are only present on the undersurface of the leaflet; gland usually conspicuous, orbicular, opposite the lower and upper pairs of pinnae; terminal seta short and thick. Flowers in axillary or terminal racemes, or when terminal the racemes more or less paniculate. Flowers 15-30 in the head, on short, stout, tomentose peduncles, subtended by small acute bracts, smaller and paler than in *A. polybotrya,* 5-merous. Calyx hoary, broadly turbinate, with short, obtuse, densely ciliate, thick lobes; bracts capitate, ciliate. Petals glabrous or nearly so, free, very thin, 1-nerved, twice the length of the calyx. Ovary hoary. Pods glaucous, 8-13 cm. long, 1 cm. broad, straight or curved, prominently contracted between the seeds; seeds longitudinal, ovate, 5-6 mm. long, about 4 mm. broad; funicle thick, navicular, capping the end of the seed.

Range.—At present it seems to be confined to Queensland, and is represented in the National Herbarium, Sydney, from the following localities:—Laidley, *C. T. White,* March, 1921; Eidsvold, *Dr. T. L. Bancroft,* March, 1918; Benarkin, *F. W. Weatherhead,* April, 1919; Planet Creek, *F. M. Bailey* July, 1904; Goodna, *C. T. White,* March, 1913; on bank of creek, Bogantungan, 220 miles west of Rockhampton, small trees 20-25 feet high, *R. H. Cambage,* No. 3982; southern parts of Queensland, *Bowman,* labelled *A. polybotrya* var. (?) in Mueller's handwriting. Bentham quotes the following localities:—Burnett River, *F. Mueller;* Ipswich, *Nernst.*

Affinity.—With *A. polybotrya,* but differing from that species in the more numerous and larger pairs of pinnæ, more numerous leaflets, paler and somewhat smaller flowers, longer, broader and more glabrous pods, and different shaped funicle. It usually flowers two or three months earlier than *A. polybotrya;* but both species appear to mature their pods about the same time.

EXPLANATION OF PLATES.

PLATE XVI.

Acacia angusta, n. sp.

(1) Lower portion of phyllodia showing the attachment and gland; (2) Twig showing phyllodes and inflorescence; (3) Phyllode; (4) Flower; (5) Bract; (6) Ovary.

Acacia semirigida, n. sp.

(7) Lower portion of phyllodia; (8) Twig showing phyllode and raceme; (9) Head of flowers; (10) Flower; (11) Bract; (12) Ovary; (13) Pod; (14) Seed and funicle.

PLATE XVII.

Acacia attenuata, n. sp.

(1) Bipinnate leaves; (2) Twig, showing phyllodes and raceme; (3) Phyllode; (4) Flower; (5) Bract; (6) Ovary; (7) Pod.

Acacia pustula, n. sp.

(8) Lower portion of phyllodia; (9) Phyllode; (10) Head of flowers; (11) Flower; (12) Bract; (13) Ovary.

PLATE XVIII.

Acacia semilunata, n. sp.

(1) Portion of branchlet showing the petiole scars; (2) Lower portion of phyllodia, showing attachment; (3) Twig, showing phyllodes and raceme; (4) Phyllode (enlarged); (5) Head of flowers; (6) Flower; (7) Bract; (8) Ovary; (9) Seed and funicle; (10) Pods.

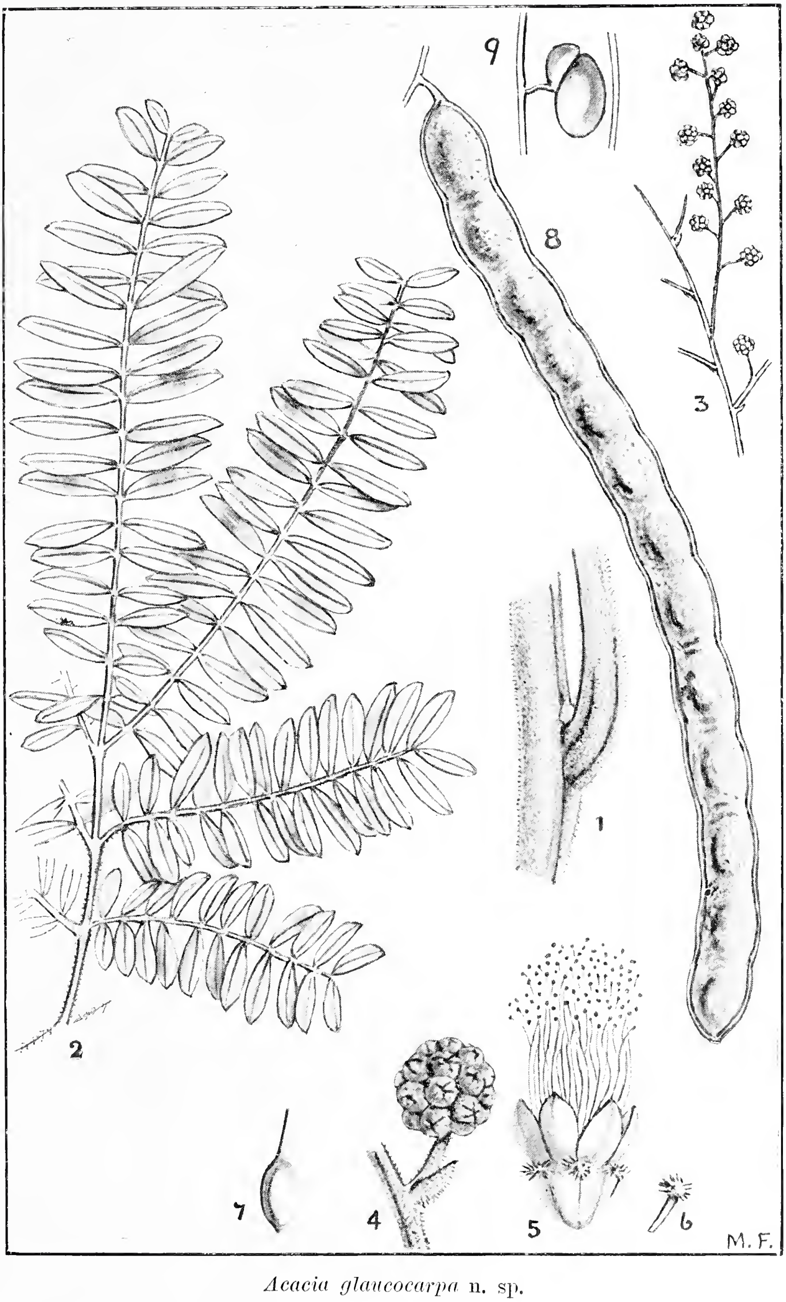
Acacia jucunda, n. sp.

(11) Lower portion of phyllodia, showing attachment; (12) Twig, showing phyllodes and racemes (natural size); (13) Head of flowers; (14) Flower; (15) Bract; (16) Ovary.

PLATE XIX.

Acacia glaucocarpa, n. sp.

(1) Petiole, showing attachment and vestiture (enlarged); (2) Pinnae or bipinnate leaves (natural size); (3) Raceme; (4) Head of flowers; (5) Flower; (6) Bract; (7) Ovary; (8) Pod (natural size); (9) Seed and funicle.



Acacia glaucocarpa n. sp.

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Notes on Tasmanian Flies of the Genus *Atherimorpha.*

By G. H. Hardy,

Walter and Eliza Hall Fellow in Economic Biology, Queensland University, Brisbane.

(*Read before the Royal Society of Queensland, 30th August,* 1926.)

In the Proceedings of the Royal Society of Tasmania, 1914, White gave descriptions of all the Tasmanian Rhagionidæ known to him, and subsequently, in 1919, when cataloguing the Australian species I was able to revise the then known genera, remove *Metoponia* which is a Stratiomyiid, and add two further genera from Tasmania. In 1921 a further alteration transferred *Clesthenia* to the *Therevidæ,* thus five genera are now left under the family. The total number of known species is now practically doubled, most of this new material being in my own collection, and although all the genera incorporate a larger number of species, no genera new to the Commonwealth have yet been discovered.

Spaniopsis and *Austroleptis* are limited to the Australian region; the former (a blood-sucking genus with five described and at least one undescribed species) may possibly not belong here; the latter, only known from Tasmania, has three species, two of which are described. *Dasyomma* is a South American genus; two undescribed Australian as well as three described Tasmanian forms appear to conform to it. *Chrysopilus* is cosmopolitan in distribution, but the number of Australian species belonging to it is uncertain; one from Tasmania, the same and another species from Sydney, and a giant of its race plentiful around the scrub-lands of Queensland are amongst them.

Special interest is centred in the genus *Atherimorpha,* as Professor M. Bezzi has described a fly under this name from South Africa. The genus had previously been regarded as one of those limited to Australia, having no very near ally in any genus known in other parts of the world. In conformity with the known distribution of other genera of the Brachycera, it was considered possible there might be found in South America either the same or a closely allied genus, or even that the range might extend to New Guinea and islands further north. That Professor Bezzi should have reported an allied species in South Africa is unexpected and so the matter becomes of considerable interest to students of Australian entomology. The definition of the genus given in my catalogue to the family needs certain modifications, and whilst making these the opportunity is taken of revising all the known forms from Tasmania, the type locality of the genus.

Genus ATHERIMORPHA White.

Atherimopha White, Proc. Roy. Soc. Tasmania, 1914, p. 41; Hardy *ibidem*, 1919, p. 119; Bezzi, Ann. South Afr. Mus. xxiii. 1926, p. 317.

Definition.—Eyes, bare, widely separated in both sexes but in the male may be either set closer together or sometimes contiguous. Seen in profile the antennae are inserted a little below the middle of the head, which position in relation to the eye is midway along the anterior margin. The antennal style is thick, being composed of several distinct annulations, five being clearly defined. The third segment appears to be complex, as on *A. fulva* this is shown to be divided into two annulations. The first segment is slightly longer than the second and the third is the longest, the style being about equal to the length of the three segments combined. The palpi attain from two-thirds to the full length of the strong projecting proboscis. Many of the bristly hairs on the thorax and scutellum are comparable in position to bristles occurring in other families of the *Diptera Brachycera*. The elongate abdomen tapers towards the apex. Intermediate and posterior tibiae have two spurs each. Wings with all veins complete and all separated at the wing margin, except sometimes the anal cell is closed. Male genitalia generally somewhat difficult to detect on dried specimens, the lamella of the female is often retracted so that it becomes difficult to determine the sexes when the eyes are widely separated in both.

Notes.—Professor Bezzi's remarks on the characters of the African species bring that form well within the definition of the genus given above except with regard to the antennae. This is said to be annulated, but in discussing another genus, *Arthroteles* (p. 321), he writes:—"In the Australian genus *Atherimorpha,* White, according to Mr. Hardy . . . . the antennal style shows some annulations at the base but this is not the case with the South African species *A. albipennis,* which I have described above." Professor Bezzi also indicates the possibility of the African species being blood-sucking, but this habit does not occur with the Australian species.

Distribution.—When describing *Atherimorpha vernalis,* White stated that a near ally occurred in New South Wales. This form has been taken on several occasions in scattered districts from Sydney to Brisbane, never in numbers and it is difficult to understand on what grounds White considered it distinct from the typical species. Since it has become possible to divide the forms occurring in Tasmania into three groups, the characters of which are consistent with the known distribution of each, the possible status of the mainland form requires further consideration, but this must await such times as a sufficient series of both sexes have been secured. When on a visit to Tasmania during January and February, 1924, I made an effort to find graduating forms between the lowland *Atherimorpha,* the male of which has widely separated eyes, and those of the higher mountains, on which form the eyes become set closer together. Mt. Wellington, near Hobart, was chosen as a suitable locality for this search, and although on the adjacent Mt. Nelson district the typical form with wide-set eyes was present in abundance, on Mt. Wellington itself none were met with until 3,000 ft. elevation was reached, this being the area from which those containing close-set eyes were originally secured. The only other known area in which this second form occurs is Cradle Mt., the faunal affinities of which are more with the west coast than with the southern area of the island. On the west coast itself, in the dense, ever-wet scrub, yet another form was found, and a year later Dr. A. Jeffries Turner took this third form, but not the second, on Cradle Mt.

These three forms may represent distinct species, but for the purposes of the present paper I regard them as races, the typical one belonging to the low-lying open forests of the eastern half of the island, the second haunting similar country on the higher mountains, the third being confined to the thick, ever-damp scrub regions on the western side, reaching a rather high elevation on Cradle Mt.

A very distinctive new species also occurs in the dense western scrub, but is apparently much rarer and is evidently the form originally referred to as a light variety of *vernalis* from Cradle Mt.

ATHERIMORPHA VERNALIS White.

Atherimorpha vernalis White, Proc. Roy. Soc. Tasmania, 1914, 42; fig. 1; Hardy, *ibidem,* 1920, p. 121, Pl. xxvii. fig. 2.

Since White described this species in 1914, the name has been attached to many specimens from both the island of Tasmania and the mainland of Australia, but it is becoming apparent that the name, as now understood, covers a complex of closely allied forms, those of Tasmania being distinguished by the following characters:—

A. vernalis vernalis White.

Readily recognised by the widely separated eyes in the male; the width of the front being one-third of the length near the antennae and two-thirds near the ocelli. The colour of the body is black and ashy-grey, whilst that of the legs varies from brown to black; the wings are more or less smoky.

Habitat.—Bagdad, Sandford, Hobart and Geeveston; 11 males, 9 females. Many other specimens from Eastern Tasmania have been seen but they are not available for study at the time of writing this paper. The form extends as far north as Launceston.

A. vernalis montana n. subsp.

This form differs from the typical one by having the eyes of the male set closer together; the width of the front at its widest part does not exceed one-eighth of the length. In other respects the form agrees with the typical one.

Habitat.—Mt. Wellington and Cradle Mt.; 10 males, 11 females. Many others have been examined. Frequents open forests.

A. vernalis occidens n. subsp.

The eyes set very closely together but to a varying extent so that the front may be very narrow, linear or absent. The whole body is conspicuously darker than that of the other two forms and the wings are heavily suffused with black.

Habitat.—Strahan: People's Park, February, 1924, 12 males. Cradle Mt., 3,000 ft. (Dr. Jeffries Turner), 2 males in the Queensland Museum. Frequents dense scrub.

ATHERIMORPHA FULVA n. sp.

Atherimorpha vernalis var. Hardy, Proc. Roy. Soc. Tasmania, 1920, p. 121.

The front of the male is narrow, at its widest part not exceeding one-fifth of the length. Both sexes are of a bright yellowish colour, with the apex of the antennae and the tips of the palpi and tarsi stained black; the markings on the thorax consist of three very thin dark longitudinal stripes, very obscure, and on each are two rows of bristly hairs. These stripes are conspicuous in *A. vernalis,* but the longer and more bristly hairs, constituting part of the vestiture, are not confined in this manner. The palpi are spatulate on the female only, on the male these organs are more cylindrical, similar to those of both sexes on *A. vernalis.* In all other respects the species appear to be similar in each case except with regard to the male genitalia which are large and conspicuous, whereas on *A. vernalis* they are inconspicuous and obviously different in outline.

Habitat.—Strahan: People's Park, February, 1924; 3 males, 1 female. Cradle Mt., the specimen in the Australian Museum referred to as a variety of *A. vernalis* evidently belongs here, but it is not available for study at the time of writing this paper. Frequents dense scrub.

The Genus *Scelio* Latreille in Australia (Hymenoptera; Proctotrypoidea.)

By ALAN P. DODD.

(*Read before the Royal Society of Queensland, 27th September, 1926.*)

Introduction.—The genus *Scelio* Latreille is known to occur throughout the world; it is one of the larger genera, as regards the number of species, of the family *Scelionidæ,* and would seem to be very strongly represented in Australia.

At various times and in many places, the species have been bred from the eggs of short-horned grasshoppers (family *Locustidæ* of Comstock, 1924), and they appear to be definitely restricted to the eggs of that family. In Australia, three species have been bred, viz.:—

S. bipartitus Kieffer (*australis* Froggatt, *ovi* Girault), from eggs of *Locusta danica* and *L. australis.*

S. fulgidus Crawford, from eggs of *Chortoicetes terminifera.*

S. chortoicetes Froggatt, from eggs of *Chortoicetes pusilla.*

Other species have been taken from Locustid egg-beds.

No stress seems to have been placed on the economic importance of these insects. However, the writer is firmly of the opinion that, in Australia, they are mainly responsible for keeping the locust plagues in check. During outbreaks of *Locusta danica* and *L. australis* in the coastal districts of North Queensland, *S. bipartitus* occurs in great numbers; the females may be seen in hundreds running over the egg-beds of the pest in question, or digging very rapidly with their forelegs in the earth in search of the host eggs. On one occasion, a cubic foot of earth taken from an egg-bed of *Locusta danica* produced 600 of the parasites and 50 locusts, giving the very efficient result of 90 per cent. parasitism.

Throughout the summer, in any district, more especially where grasshoppers are abundant, females of the various species may be collected running rapidly over bare or sandy soil; they are exceedingly active and difficult to capture. Occasionally a male may be taken where the females occur, but they appear comparatively rare; most of the males in my collection have been captured with a sweeping net. In a count of 264 bred individuals of *S. bipartitus,* 16 only were males.

The first member of the genus from Australia was described by Walker in 1839; in the last twenty years, Kieffer, Froggatt, Crawford, Girault, and Dodd have added species, and the number of described species from this country has now reached the total of twenty-nine and one variety.

During the past several years I have been gradually gathering material of this genus, and having amassed a considerable collection, including large series of many of the species, now feel in the position to attempt a much needed revision of the group. For the purposes of the present paper, I have examined the types of all previously described species, with the exceptions of *australiensis* Kieffer, *fulgidus* Crawford, *pulchellus* Crawford, and *froggatti* Crawford; however, in the case of the last three species I have seen examples of the type series. *Australiensis* is unknown to me, and the original description is not of sufficient length to permit of its identification.

Of the 29 described species, 13 and the variety are considered synonyms by the writer, thereby reducing the number of valid species to 16. To these are added in this paper 13 new species and 3 new varieties, bringing the total to 29 species and 3 varieties.

The species *Scelio shakespearei* Girault (1926) is wrongly placed, and belongs to the genus *Sceliomorpha* Ashmead.

SCELIO LATREILLE and *SCELIOMORPHA* ASHMEAD.

Among the genera of the *Scelionidæ*, the genus *Scelio* is peculiar in that there is a reduction in the number of the male antennal joints, the antennæ being 10-jointed in the male, 12-jointed in the female.

In Australia, *Scelio* might be confused with one other genus, namely, *Sceliomorpha* Ashmead, as the writer understands the latter genus. Both of these genera are strongly represented in our fauna, and the species are very similar in general size, colour, shape, and structure; *Scelio* is the more compact segregate, the species showing less diversity in structure. The two genera may be separated by means of the following characters:—

Male antennæ 10-jointed; propodeum without a complete longitudinal carina on either side; segment 1 of abdomen without a raised median area, segment 2 transversely depressed at base; forewings with the basal portion distinctly paler, and with a more or less distinct stigmal spot .. .. .. *Scelio* Latreille.

Male antennæ 12-jointed; propodeum with a complete longitudinal carina on either side some distance from the median line; segment 1 of abdomen at meson with a raised prominence or flat area bounded laterally by a strong stria or carina, segment 2 not depressed at base: forewings uniformly stained, not distinctly paler at base, without a stigmal spot .. *Sceliomorpha* Ashmead.

These distinctions hold true throughout a long series of species. In addition, other characters can frequently be utilised; some of these may be stated as follows:—

Frontal depression always narrow, shallow, and not margined above; vertex of head sloping gradually to the occiput; anterior margin of mesoscutum always sloping gradually to the pronotum; scutum never with a median carina; postscutellum usually inconspicuous, always transverse, and not excavated on its dorsal surface; venation sometimes faint and obliterated; segment 2 of abdomen (except in *concinnus*) shorter than 3 or 4 *Scelio* Latreille.

Frontal depression of head (except in *solitaria*) broad, deep, and margined above; vertex often precipitous towards the occiput; anterior margin of scutum often abruptly sloping to the pronotum; scutum sometimes with a median carina; postscutellum prominent, transverse or quadrate, if transverse its dorsal surface is excavated; venation always distinct; segment 2 of abdomen as long as 3 and plainly longer than 4 .. .. *Sceliomorpha* Ashmead.

The genus *Discelio* Kieffer is, in my opinion, not valid; the character of the bidentate or concave postscutellum is met with in several of the Australian species, and while useful as a specific distinction, has little, if any, generic value.

In passing, it is worthy of remark that in another genus closely related to *Scelio*, namely *Sparasion* Latreille, which occurs in America, Europe, and Asia, no Australian representative has yet been recorded.

Characters of the Species.

In attempting this revision, a great deal of thought has been given to the question of reliable characters on which to base or distinguish species. The similarity in the wings and antennæ of all the species is so marked that no specific characters could be found in these appendages. I have relied chiefly on the sculpture of the head, mesoscutum, scutellum, and abdomen and the stoutness of the thorax, and to a lesser extent of the abdomen; the length of the first abdominal segment has proved a highly useful character; the pilosity of the head and thorax has been used for a few species; while the concavity of the postscutellum, utilised by Kieffer to distinguish the genus *Discelio*, is an easily recognised difference in a number of cases.

Six species are recognised in which at least the thorax is bright reddish or yellowish, but in one only, *nigricornis*, has a series of specimens been seen. In a very long series of that species, the variation is considerable, from a wholly clear thorax to one which is black except for deep red on its sides; yet in some localities *nigricornis* appears to remain constant in colour. Very probably it will be found that the other red species will vary to a much less degree.

Throughout this paper, the female has been chosen as the dominant sex, for several reasons. In the first place, males are on the whole of rare occurrence, and in many of the species are not known; secondly, the differences in sculpture in related species is much more apparent in the female; indeed, in species whose females are readily separated, it may be almost impossible to distinguish the males.

The degree of difference in the sculpture of the sexes is of interest. Usually, in the male the punctuation of the head and thorax is much coarser and closer than in the female; for instance, the punctures of the head and mesoscutum may be circular and not confluent in the female, whereas in the male of the same species they may be not only confluent but reticulate. On the other hand, the striation of the abdomen is generally weaker and sparser in the male. In two species, *nigricornis* and *contractus,* the male wings are perfectly hyaline.

With regard to colour, as a rule the legs in the male are darker; red coxæ in the female may be black in the male, and clear femora become black or dusky. In many species, where the basal joints of the antennæ are testaceous in the female, in the male the antennæ are wholly black; but the reverse is true in *flavicornis,* and to a lesser degree in *bipartitus* and *perspicuus.* Of the females with reddish thorax, the male is known in *nigricornis* only, and is wholly black; this suggests the question whether the males of all species will not be found to be black.

Notes on the Distribution of the Species.

Practically the whole of my collection has been made in Queensland, except for one or two localities in northern New South Wales. Thus, of the 29 species recognised herein, 23 have been taken in Queensland. Nine of the Queensland species are known to occur in New South Wales, together with *chortoicetes* Froggatt and *australiensis* Kieffer, the second of which is unknown to me. No species have been seen from Victoria. Two species, *gobar* Walker and *diemenensis* Dodd, occur in Tasmania; the latter is very closely related to *planithorax* Dodd and *ignobilis* Dodd from Queensland, while *gobar* also is probably connected with the same group. From South Australia comes *parvicornis* Dodd, nearly allied to the *punctaticeps-ignobilis* group. In South-west Australia occurs *nigricornis,* which has a further known range extending from the Northern Territory to New South Wales. *Nigricornis, bipartitus,* and *erythropus* have been found in the Northern Territory; the former two are common Queensland species, but *erythropus,* which has no apparent near relatives, has not been taken elsewhere.

In Queensland, the majority of my collecting has been carried out along the coast, and it is probable that most of the coastal forms are now known. Five species, *concinnus, cruentatus, nigrobrunneus, fulgidus,* and *contractus,* have not been obtained from any coastal district, and may be purely inland forms. The two common coastal species, *nigricornis* and *bipartitus,* extend inland at least as far as Chinchilla, 170 miles from the coast in a direct line. Another common coastal form, *flavicornis,* has not been taken inland.

Considerable collecting extending over several seasons has been effected in three districts in Queensland, namely, Cairns, including the Atherton tableland, in the north; Brisbane, including Mt. Tambourine and the Blackall Range, in the south; and Chinchilla, on the western edge of the Darling Downs. A comparison of the species known from each of these localities may be of interest.

From the Cairns district have been secured the following twelve species:—*Varipunctatus, fulvithorax, ignobilis, nigricornis, flavicornis, notabilis, sulcaticeps, orientalis, punctaticeps, nigriscutellum, bipartitus,* and *asperatus.*

From Brisbane have been collected six of the foregoing—*ignobilis, asperatus, bipartitus, flavicornis, nigricornis,* and *orientalis; punctaticeps* is replaced by a closely allied *striatifacies,* and *notabilis* by the somewhat similar *amoenus;* and there occurs also *planithorax, pilosifrons, improcerus,* and *perspicuus,* or a total of twelve species for the locality.

From Chinchilla have been taken *nigricornis, bipartitus,* and *asperatus,* occurring at both Cairns and Brisbane; *nigriscutellum* known from Cairns but not from Brisbane; *striatifacies, pilosifrons,* and *perscipuus,* occurring at Brisbane but not at Cairns; and *nigrobrunneus* and *contractus,* not known from either of the other districts.

Thus of 12 species from Cairns, 5 have not been found at Brisbane or Chinchilla; of 12 species from Brisbane, 3 have not been taken at Cairns or Chinchilla; and of 9 species from Chinchilla, 2 have not been collected at Cairns or Brisbane.

Moree, New South Wales, lies about 200 miles almost due south of Chinchilla, at approximately the same elevation and distance from the coast; both localities are on the eastern edge of the great inland slope, and the type of country and vegetation is very similar. Six species of *Scelio* have been secured from Moree, namely, *nigrobrunneus, nigricornis, pilosifrons, perspicuus, asperatus,* and *fulgidus;* it is significant that the first five occur at Chinchilla, while *fulgidus* has been taken at Roma, 100 miles west of the latter town.

Several species have been collected in the tropical jungle of the Queensland, as opposed to the ordinary open grassy forest country; these are *varipunctatus, sulcaticeps, amoenus, notabilis,* and *orientalis. Sulcaticeps* and *varipunctatus* are very distinctive insects, while *amoenus, notabilis,* and *orientalis,* together with *nigrobrunneus* from the inland brigalow (*Acacia harpophylla*) scrubs, form a more or less well-defined group of species.

KEY TO THE AUSTRALIAN SPECIES.

1. Males .. .. 32.
   Females .. .. 2.

2. Thorax for the most part red or reddish .. .. 3.
   Thorax black .. .. 9.

3. Apical antennal joints contrasting pale yellow. Head and posterior half of abdomen black, scutum and scutellum confluently punctate; segments 2-5 of abdomen finely densely striate .. .. *erythopus* Dodd.
   Antennae black, except sometimes the basal joints .. .. 4.

4. Anterior half of scutum smooth; segments 4 and 5 of abdomen smooth; head with a few scattered punctures .. .. .. *concinnus* new species.
   Scutum and segments 4 and 5 of abdomen wholly punctate or striate; head with dense punctures .. .. 5.

5. Segment 3 of abdomen striate .. .. 6.
   Segment 3 of abdomen mostly or in part reticulate .. .. 7.

6. Size larger; abdomen red, except at apex; frons and vertex reticulate-punctate; towards occiput with definite transverse striae; postscutellum not concave; segment 3 of abdomen very definitely striate, the surface between finely sculptured .. .. *cruentatus* Dodd.

Size smaller; abdomen black; punctuation of frons and vertex confluent but not reticulate; no definite transverse striae towards occiput; postscutellum concave; segment 3 of abdomen showing definitely reticulate as well as striate .. .. *nigriscutellum pretiosus* new variety.

7. Postscutellum not concave or bidentate; frons reticulate-punctate, with a conspicuous silvery pubescence; segment 3 and sometimes 4 of abdomen finely reticulate, 4 and 5 very finely striate .. .. .. *nigricornis* Dodd.

Postscutellum concave at meson; frons densely punctate but not reticulate; segment 3 in part striate, the striae of 4 and 5 stronger .. .. 8.

8. Size larger; pubescence of frons rather conspicuous; towards occiput with noticeable transverse striae; lateral margins of propodeum not incised just before posterior angles; reticulate area of segment 3 broad *fulvithorax* new species.

Size smaller; pubescence of frons very fine and inconspicuous; no transverse striae towards the occiput; lateral margins of propodeum incised just before posterior angles which are thus prominent .. *nigriscutellum* Dodd.

9. Scutum with scattered punctures, the parapsidal furrows absent.

Legs mostly piceous .. .. *varipunctatus* Dodd.

Legs, except the tarsi, clear testaceous *varipunctatus claripes* new variety.

Parapsidal furrows complete, if apparently absent, the punctuation is dense 10.

10. Vertex of head toward the occiput strongly sublongitudinally grooved.

Median lobe of scutum with numerous scattered punctures, the parapsides mostly smooth .. .. *sulcaticeps* new species.

Vertex of head towards the occiput punctate or transversely striate .. 11.

11. Scutum not uniformly punctate, smooth for the anterior portion of the median lobe .. .. 12.

Scutum wholly punctate, not smooth anteriorly .. .. 15.

12. Segment 3 of abdomen finely reticulate, 4 and 5 hardly sculptured, almost smooth .. .. *chortoicetes* Froggatt.

Segments 3-5 of abdomen striate .. .. 13.

13. Thorax stout, the propodeum short; parapsides, posterior half of median lobe, and the scutellum with large confluent punctures .. .. .. 14.

Thorax slender, the propodeum long; parapsides smooth; posterior portion of median lobe, and the scutellum with small non-confluent punctures *fulgidus* Crawford.

14. Segment 1 of abdomen transverse; scutum confluently punctate; parapsidal furrows rather obscure .. .. *perspicuus* new species.

Segment 1 hardly shorter than its basal width; scutum reticulate-punctate; parapsidal furrows rather distinct .. *perspicuus littoralis* new variety.

15. Segment 3 of abdomen for the most part finely reticulate, segment 1 transverse .. .. 16.

Segment 3 striate, segment 1 variable .. .. 19.

16. Frons and cheeks with a conspicuous silvery pubescence; reticulation of segment 3 not raised; scutum and scutellum rugose or reticulate-punctate .. 17.

Frons and cheeks without noticeable silvery pubescence; reticulation of segment 3 raised, the segment showing also definite striæ; punctuation of scutum and scutellum not reticulate .. .. *improcerus* new species.

17. Postscutellum not concave; thorax showing reddish, at least on the pleuræ *nigricornis* Dodd.

Postscutellum concave at meson; thorax wholly black .. .. .. 18.

18. Frons and vertex with scattered punctures .. .. *pilosifrons* new species.

Frons and vertex with large confluent punctures .. *contractus* new species.

19. Upper frons with longitudinal striæ; head and part of thorax with stiff silvery pubescence . .. . *flavicornis* Dodd.

Upper frons without striæ; head and thorax with fine pubescence, except in *bipartitus* .. .. 20.

20. Head, and thorax more or less, with a rather stiff silvery pubescence; head, scutum, and scutellum reticulate-punctate; abdomen slender, three times as long as its greatest width, segment 1 hardly shorter than its greatest width *bipartitus* Kieffer.

Pubescence of head and thorax not silvery, or if pale it is very fine and inconspicuous .. .. 21.

21. Scutum very definitely reticulate-punctate, the sculpture large and shallow, contrasting with the smaller non-reticulate punctures of the frons .. *asperatus* new species.

Scutum with large or small punctures, rarely with a slight reticulate tendency, the punctuation not contrasting with that of the frons .. .. 22.

22. Thorax stout, from lateral aspect not much longer than high, the propodeum abruptly declivous; segment 1 of abdomen short and transverse (except in *orientalis*); punctures of head, scutum, and scutellum larger .. .. 23.

Thorax not so stout, from lateral aspect much longer than high, the propodeum not abruptly declivous; segment 1 as long as its basal width (except in *improcerus*); punctures of head, scutum, and scutellum smaller .. 26.

23. Segment 1 of abdomen as long as its basal width; head, scutum, and scutellum with large confluent or sub-confluent punctures .. .. *orientalis* Dodd.

Segment 1 transverse, much shorter than its basal width .. .. .. 24.

24. Head toward occiput with two or three sub-transverse grooves separated by carinae; punctures of scutum separated by irregular longitudinal carinae or rugae; parapsidal furrows not punctate or rugose *notabilis* new species.

Head toward occiput with transverse rows of confluent punctures; scutum without raised striae or rugae; parapsidal furrows punctate or rugose .. 25.

25. Abdomen wholly black, the striae very strong, the rugose sculpture between the striae on segment 3 quite strong; scutum highly polished, the punctures dense but not confluent .. .. *amoenus* new species.

Abdomen in part deep red, the striae finer, the rugose sculpture between the striae on segment 3 fine; scutum not highly polished, the punctures confluent with a reticulate tendency .. .. .. *nigrobrunneus* new species.

26. Segment 1 of abdomen transverse; postscutellum concave or bidentate; segment 3 of abdomen more or less definitely reticulate between the striae .. *improcerus* new species.

Segment 1 of abdomen as long as its basal width, segment 3 hardly or very finely sculptured between the striae; postscutellum not concave .. 27.

27. Parapsidal furrows widened; punctures of scutum more or less reticulate; punctures of frons scattered; coxae dark, the femora dusky, the antennae wholly black; segments 4 and 5 of abdomen broadly smooth at the meson .. *parvicornis* Dodd.

Parapsidal furrows not widened, sometimes obscure; punctures of scutum dense or sub-confluent, without a reticulate tendency .. .. 28.

28. Mesopleurae with confluent punctures and longitudinal striae; coxae black; antennae wholly black; punctures of frons and vertex dense; posterior angles of propodeum truncate .. .. *striatifacies* Dodd.

Mesopleurae densely but not confluently punctate, and without striae .. 29.

29. Posterior angles of propodeum truncate; parapsidal furrows obscure; segments 3-5 of abdomen wholly striate; frons densely punctate; coxae and scape testaceous .. .. *punctaticeps* Dodd.

Posterior angles of propodeum rounded; parapsidal furrows rather distinct; segments 3-5 of abdomen more or less smooth at meson .. .. 30.

30. Punctures of frons dense; coxae and scape testaceous; abdomen stout, a little more than twice as long as its greatest width .. *ignobilis* new species.

Punctures of frons rather scattered .. .. 31.

31. Parapsidal furrows not very distinct; abdomen $2\frac{1}{2}$ times as long as its greatest width; coxae dark, femora dusky; antennae wholly black *diemenensis* Dodd.
Parapsidal furrows distinct; abdomen almost three times as long as its greatest width; coxae, femora, and scape testaceous .. *planithorax* new species.

32. Scutum wholly confluently or reticulate-punctate .. .. 34.
Scutum with a smooth area anteriorly .. .. 33.
Scutum with large scattered punctures .. .. .. Undescribed species.

33. Parapsides, posterior half of median lobe, and the scutellum, with large confluent punctures; head with large dense punctures; antennae becoming testaceous apically .. .. *perspicuus* new species.
Parapsides smooth; posterior half of median lobe and the scutellum with small non-confluent punctures; head with small scattered punctures; antennae wholly black .. .. *fulgidus* Crawford.

34. Segment 3 of abdomen finely polygonally reticulate; segment 1 transverse; antennae wholly black; wings hyaline .. .. 35.
Segment 3 of abdomen striate like 2 or 4 .. .. 36.

35. Postscutellum concave at meson; abdomen stout, twice as long as its greatest width .. .. *contractus* new species.
Postscutellum not concave at meson; abdomen slender, three times as long as its greatest width .. .. *nigricornis* Dodd.

36. Postscutellum concave at meson; segment 1 of abdomen transverse .. *improcerus* new species.
Postscutellum not concave at meson; segment 1 of abdomen rarely a little shorter than its basal width .. .. 37.

37. Antennae testaceous, except at base; frons with conspicuous silvery pubescence .. .. 38.
Antennae black, rarely tinged with brown apically; pubescence of frons fine .. .. 39.

38. Abdomen stouter, segments 3 and 4 fully twice as wide as long; propodeal angles rounded; funicle 3 of antennae not much larger than 2 or 4 *flavicornis* Dodd.
Abdomen slender, segments 3 and 4 not greatly wider than long; propodeal angles sub-acute; funicle 3 of antennae distinctly larger than 2 or 4 *bipartitus* Kieffer.

39. Thorax stouter, from lateral aspect not greatly longer than high, the propodeum declivous .. .. 40.
Thorax more slender, from lateral aspect about twice as long as high, the propodeum not abruptly declivous .. .. 41.

40. Scutum and scutellum confluently punctate, with a slight reticulate tendency *orientalis* Dodd.
Scutum and scutellum more definitely reticulate-punctate, the punctures much larger .. .. *asperatus* new species.

41. Femora piceous; segments 4 and 5 of abdomen smooth at meson .. *striatifacies* Dodd.
Femora clear testaceous; segment 5 of abdomen smooth at meson .. *punctaticeps* Dodd.

Notes on the Key.

Two species, *gobar* Walker and *australiensis* Kieffer, are not included in the key; the former is evidently distinct, while the latter is unknown to the writer.

In the key I have endeavoured, as far as possible, to present the species in their natural relationships. For simplicity, the species with a red thorax have been separated at once from those in which the thorax is black; owing to the great variation in colour, the female of *nigricornis* has been placed twice, once among the red species and again among its close relations in the black species. On account of the sculpture of segment 3 of the abdomen showing reticulation more or less as well as striation, the female of *improcerus* also has been included twice.

The six species, *parvicornis, striatifacies, punctaticeps, ignobilis, diemenensis,* and *planithorax,* form a homogenous group; *nigricornis, pilosifrons,* and *contractus* form a closely-related group of three species; while *orientalis, amoenus, notabilis,* and *nigrobrunneus,* although differing in many respects, have a number of characters in common.

Although, owing to the marked similarity of many of the species, comparison of a series of species is necessary for correct identification, the writer is hopeful that the foregoing key will facilitate determination.

As the terms "reticulate-punctate" and "confluently-punctate" have been used to a considerable extent throughout this paper, here it may be well to define their meaning. When the circular punctures of the head and thorax are dense but distinctly separated, I have used the expression "dense but not confluent." When the margins of the punctures coincide while still keeping their circular character, the term "confluently-punctate" has been given. And when the margins of the punctures join to such an extent that the circular character is lost, the margins being broken, angled, or polygonal, the term "reticulate-punctate" has been employed. In such a case as that of *asperatus,* the reticulate-punctures of the mesoscutum are so large and shallow that the punctate character might well be lost sight of, and the sculpture almost be termed openly reticulate.

SCELIO sp.

S. parvicornis (part) Dodd, Proc. Royal Soc. of Q'land, Vol. XXVI., 1914, p. 113.

Male.—Length, 3·75 mm.

Black; legs reddish-yellow, the coxae black, the femora dusky; antennae black, brownish toward apex.

Head normal; vertex and upper frons coarsely rugose- or reticulate-punctate, arranged transversely toward the occiput, and with a conspicuous fine long pubescence; antennal impression large and smooth, on either side with a smooth area bearing a few small punctures, against the eye margins with dense punctures continued from the upper frons; against the mouth there are a few very short striae; cheeks rugose-punctate dorsally, smooth except for a few punctures on their ventral half. Antennae normal; scape rather stout; pedicel short, hardly longer than its greatest width; funicle 1 slightly longer than the pedicel, a little longer than its greatest width; 2 somewhat wider than long; 3 a little larger than 2 or 4, slightly wider than long; 4-7 plainly wider than long. Thorax rather stout; scutum smooth, with large scattered punctures, the parapsidal furrows deep and distinct; scutellum smooth, with a few scattered punctures; mesopleurae striate. Forewings subhyaline, the venation pale yellow. Abdomen stout; segment 1 much shorter than its basal width, strongly striate; 2-6 very densely finely striate and with a noticeable pubescence on 3-7.

Female.—Unknown.

Habitat.—South Australia (exact locality unknown).

The insect on which this description was based was in the collection of the Macleay Museum, mounted on the same card as the type of *parvicornis,* and was originally described as the male of that species. The body of the unique specimen has been lost, but the forewings and antennae are present on a slide with the forewing and antennae of the type of *parvicornis* in the Macleay Museum.

The sparse punctuation of the scutum and scutellum is peculiar; obviously, this specimen represents an undescribed species of which the female is not yet known.

SCELIO AUSTRALIENSIS Kieffer.

Bull. Soc. Hist. Nat., Metz, 1905, p. 100.

S. australiensis Kieffer, Ann. Soc. Scient., Brussels, 1908, p. 133.

S. australiae Kieffer, Genera Insectorum, 1910, p. 74.

Female.—Length, 4 mm.

Black; mandibles, coxae, and legs red; scape and pedicel of a red-brown.

Head with large dense punctures, not confluent; mouth with converging striae; a smooth hardly depressed area above antennal insertion. Funicle 1 longer than wide, a little longer than 2; 3-10 forming a club and twice as wide as long. Thorax confluently punctate; parapsidal furrows evident anteriorly. Wings brown, except the basal third; nerves indistinct, except a trace of a yellow oblique stigma and the stigmal vein. Abdomen striate on all the surface, a narrow smooth posterior border of the segments.

Habitat.—New South Wales: Mount Victoria.

Type.—Probably in some European museum.

The above description is a translation of the original, and is insufficient to determine the species. It might well fit many of the described species. I have seen no representatives of the genus from the Blue Mountains; possibly collecting in the locality would rediscover the species.

I have already pointed out that Kieffer described this insect twice as a new species in almost identical words, and under the same name; later, evidently believing that the two descriptions referred to different species, he proposed the name *australiae* for the second.

SCELIO GOBAR Walker.

Monograph. Chalcid. Vol. 2, p. 61, 1839.

Female.—Length, 4 mm.

Black, the antennae concolorous, the pedicel brownish; coxae black, the femora dusky, the tibiae and tarsi yellow.

Frons with large confluent punctures, the lower half with striae converging toward the mouth; centre of vertex partly smooth. Scutum and scutellum coarsely reticulate-punctate; parapsidal furrows present. Abdominal segments wider than long, 3 a little the longest; 1 strongly striate, the rest finely striate and granulate, the striae absent at the meson. Forewings normal; dusky; submarginal vein not distinct; a distinct stigmal spot involves almost all the stigmal vein. Pedicel longer than funicle 1 and longer than its greatest width.

Male.—Head coarsely reticulate-punctate, also scutum and scutellum; stigmal spot not marked.

Habitat.—Tasmania.

Type.—In the British Museum.

The above brief description was made some years ago by the writer from an examination of the type material. Unfortunately it is not full enough to allow of the species being included in the table, but enough characters are given to permit recognition. The only other known *Scelio* from Tasmania, *diemenensis*, can apparently be distinguished from *gobar* in the small non-confluent punctures of the frons, the finer punctuation of the thorax, the indistinct parapsidal furrows.

SCELIO SULCATICEPS new species.

Female.—4·10 mm.

Black; abdomen suffused with deep red on segments 2 and 3; legs clear reddish-yellow, the coxae darker at base; antennal scape red, the pedicel reddish, the remaining joints fuscous.

Head normal; eyes larger, the space between not so wide as usual; ocelli very large; vertex between the ocelli smooth and shining, except for several punctures just behind the anterior ocellus; behind the posterior ocelli, medially, there is a transverse row of four large punctures and a short oblique row of three punctures on either side; behind these punctures are eleven strong longitudinal grooves or sulci running to the occiput, the lateral grooves rather oblique and continued down the cheeks; cheeks rather narrow, with large confluent punctures forming two long sulci; frons shining, with large circular punctures, numerous but not confluent, laterally forming two longitudinal rows which are continued for some distance on either side of the antennal impression; these rows give way to three strong striae on either side converging to the mouth; antennal impression long, rather broad, smooth; punctures of head each with a fine pale seta, the pubescence not conspicuous. Antennal scape as long as the next five joints combined; pedicel almost twice as long as its greatest width; funicle 1 a little shorter and narrower than the pedicel, twice as long as its greatest width; 2 and the following transverse; division between funicle 5 and 6 (if the club is counted as 6-jointed, these are joints 1 and 2 of the club) oblique. Thorax stout; from lateral aspect as high as long, the propodeum rather abruptly declivous; from dorsal aspect not much longer than its greatest width; pronotum with large dense punctures bearing long dark setae; parapsidal furrows consisting of a row of large sub-confluent punctures; median lobe of the scutum with numerous large circular punctures bearing long fine setae, and there is a row of confluent smaller punctures forming a one-half complete median groove from the posterior margin; parapsides smooth except for a row of large punctures against the anterior and lateral margins and a very few (about four) smaller punctures on its surface; scutellum with large circular punctures, dense but not confluent; postscutellar plate prominent, transverse, rather deeply concave at meson; propodeum short, coarsely rugose-punctate, laterally with white pubescence, very short at the meson where there are three circular foveae; mesopleurae for the most part rather densely finely punctate, with a small smooth central area, against the tegulae with two or three deep longitudinal grooves; metapleurae strongly confluently punctate. Forewings lightly yellow throughout, the base hardly paler; venation pale yellow, distinct, the stigmal vein and spot a little darker. Abdomen a little less than three times as long as its greatest width; segment 1 about one-half as long as its basal width; 2 somewhat longer than 1; 3 slightly longer than 2, about twice as wide as long; 4 slightly shorter than 3, not much shorter than the width at its posterior margin; 5 somewhat shorter than 4, plainly longer than the width at its posterior margin; 6 as long as its basal width; 1 rather strongly striate, and finely rugose between the striae; 2 and 3 finely striate, densely granulate or coriaceous between the striae, striae denser on 2 than on 3, somewhat wavy and irregular in outline; 4 and 5 with straight stronger and rather sparser striae, failing at the median line of 4, the granulate sculpture fine on 4, not noticeable on 5; 6 densely punctate.

Male.—Unknown.

Habitat.—North Queensland: Kuranda, one female taken on the ground in the jungle, in April.

Type.—South Australian Museum, I. 16071.

The type is unique. The species has no near relations, and can be readily recognised by the longitudinal grooves toward the posterior margin of the head dorsally. In the stout thorax, and the length of the abdominal segments it approaches *notabilis* and *amoenus*. The eyes and ocelli are much larger than is usual in the genus. Perhaps the oblique division between joints 7 and 8 of the antennae is an individual peculiarity, and would not hold in a series of specimens.

SCELIO VARIPUNCTATUS Dodd.

Archiv fur Naturgeschichte, Berlin, Vol. 80, 1915.

Female.—Length, 3·75 mm.

Black; legs, including the coxae, piceous, brownish at the base of the femora and tibiae, the trochanters yellow, the anterior tibiae and tarsi dusky-yellow; antennae black, the pedicel and base of the scape brownish; tegulae dark.

Head normal, the vertex less transverse than usual; vertex and upper frons smooth, with a few scattered circular punctures of moderate size; toward the occiput the punctures are rather dense but not confluent; antennal impression large and smooth, on either side with numerous circular punctures, against the mouth with a few short striae; cheeks confluently punctate; punctures bearing fine setae but the pubescence is not conspicuous. Antennal scape as long as the next four joints combined; pedicel about twice as long as its greatest width; funicle 1 slightly longer than the pedicel, almost three times as long as its greatest width; 2 quadrate, the following joints wider than long but less transverse than usual. Thorax, from lateral aspect, one-half longer than high, the propodeum not abruptly declivous; from dorsal aspect, a little less than twice as long as its greatest width; pronotum densely punctate and pubescent; parapsidal furrows wanting; scutum and scutellum smooth, with scattered rather small punctures bearing long fine setae; post-scutellar plate very short and transverse; propodeum moderately long, its posterior angles sub-truncate, densely punctate, with white pubescence laterally, at meson at its base with two divergent carinae running obliquely to the posterior angles; mesopleurae with dense punctures, not confluent, dorsally with a smooth impunctate area; metapleurae confluently punctate. Forewings very deeply smoky, the base somewhat paler; venation dusky and distinct, the stigmal spot very dark. Abdomen slender, three times as long as its greatest width; segment 1 two-thirds as long as its width at base; 2 two-thirds longer than 1; 3 a little longer than 2, not greatly wider than long; 4 a little shorter than 3, fully as long as the width at its posterior margin; 5 somewhat shorter than 4, almost as long as the width at its anterior margin and much longer than the width at its posterior margin; 6 from lateral aspect somewhat convex, hardly more than one-half as long as 5, no longer than its width at base; 1 sparsely striate, between the striae hardly sculptured; 2 rather sparsely striate, between the striae densely punctate, its posterior margin broadly smooth; 3 and 4 sparsely, finely striate and with scattered pin-punctures bearing short fine setae, broadly smooth at the meson except at the base of 3; 5 more strongly striate, narrowly smooth at the median line; 6 densely punctate and pubescent.

Male.—Unknown.

Habitat.—North Queensland: Cairns district, one female in February (type); Innisfail, one female in November, A. P. Dodd.

Type.—South Australian Museum, I. 11090.

A peculiar species, readily recognised by the sparsely punctate mesoscutum and absence of parapsidal furrows.

SCELIO VARIPUNCTATUS CLARIPES new variety.

Female.—Differs from the typical form in having the legs, including the coxae, bright reddish-yellow, the tarsi fuscous; antennal scape suffused with red.

Male.—Unknown.

Habitat.—North Queensland: Mossman, one female in April (type); Cairns district, one female in May, A. P. Dodd.

Type.—South Australian Museum, I. 16070.

Paratype.—In the author's collection.

SCELIO PERSPICUUS new species.

Female.—Length, 3·5-4·5 mm.

Black; legs, including the coxae, bright reddish-yellow; antennae black, the scape reddish-yellow, the next two joints more or less yellowish.

Head normal; frons densely punctate, but not confluently so, the punctures moderately large, the surface between finely alutaceous; vertex smooth, with numerous scattered punctures; toward the occiput are several strong transverse striae or carinae, between which are confluent punctures; pubescence fine and not conspicuous; face on either side of the smooth antennal impression with strong striae converging to the mouth; cheeks rather broad, coarsely confluently punctate. Antennae normal; pedicel one-third longer than its greatest width; funicle 1 cupuliform, somewhat distinctly longer than the pedicel, the remaining joints transverse. Thorax stout; from dorsal aspect one-third longer than its greatest width; from lateral aspect slightly longer than high, the propodeum rather abruptly declivous; pronotum coarsely shallowly rugose-punctate and with conspicuous stiff pubescence; scutum with large circular confluent punctures, the anterior two-fifths to one-half of the median lobe smooth and shining and without sculpture except for a few scattered obscure punctures bearing pale setae; parapsidal furrows very obscure, consisting of a row of rugose punctures; scutellum with large confluent punctures; postscutellum prominent as a transverse emarginate rugose plate; propodeum short at meson, its posterior angles truncate, densely rather finely punctate, laterally with silvery pubescence; propleurae confluently longitudinally punctate; mesopleurae strongly striate above, its depression rather finely densely punctate in more or less regular longitudinal lines; metapleurae rather strongly confluently punctate. Forewings normal; deeply smoky, the basal portion paler and yellowish; venation pale, very obscure; a small distinct stigmal spot is present. Abdomen moderately slender, 2½ times as long as its greatest width; segment 1 hardly more than one-half as long as its basal width; 2 one-half longer than 1; 3 a little yet distinctly longer than 2, no more than twice as wide as long; 4 hardly shorter than 3; 5 rather distinctly shorter than 4, as long as the width at its posterior margin; 6 two-thirds as long as 5, almost as long as its basal width; 1 strongly striate, rugose between the striae; 2 rather strongly striate and finely coriaceous between the striae; 3 striate, and between the striae finely rugose or coriaceous, the striae curving away somewhat from the median line which is thus granulate and devoid of striae; striae on 4 straight, the surface granulate, the striae failing at the meson; 5 sparsely striate, hardly sculptured between the striae, with a few small punctures posteriorly; 6 rugose-punctate and pubescent.

Male.—Coxae fuscous; antennal scape and pedicel black or fuscous, the remaining joints bright yellow-brown.

Frons and vertex confluently reticulate-punctate, toward the occiput with a transverse arrangement, the surface also finely alutaceous. Smooth anterior area of median lobe of the scutum with scattered large punctures, the punctures of the posterior half very irregular in size and arranged in five longitudinal lines; parapsidal furrows quite distinct. Forewings subhyaline, the venation distinct, the submarginal vein yellow, the stigmal vein dark. Segments 3-6 of abdomen with fine striae and rather dense short fine pubescence. Antennal scape moderately long and stout; pedicel small, no longer than its greatest width; 2 quadrate; 3 a little yet distinctly longer than 2, a little longer than wide; 4 a little narrower and plainly shorter than 3, one-half wider than long; 4-7 subequal.

Habitat.—South Queensland: Chinchilla, six females, one male, in January and February; Morven, one female, in March. New South Wales: Moree, one female, in January.

Type.—South Australian Museum, I. 16069.

Allotype.—In the author's collection.

Paratypes.—In the Queensland Museum and the author's collection.

The species is easily distinguished by the smooth area on the mesoscutum anteriorly. In *chortoicetes* and *fulgidus* the scutum is partly smooth, but these species bear small punctures and are very different in general appearance. In the stout thorax and the large size of the punctures of the head, and thorax, *perspicuus* approaches *orientalis, amoenus,* and *notabilis.*

SCELIO PERSPICUUS LITTORALIS new variety.

Female.—Differs from the typical form in several particulars. The sculpture of the scutum is rugose- or reticulate-punctate; the anterior smooth area is rather smaller and bears more definite scattered punctures; the parapsidal furrows are shallow, rugose, but quite distinct; the scutellum is reticulate-punctate; the postscutellum is not so prominent;

there is a narrow smooth area against the anterior margin of the mesopleural depression for its ventral half; segment 1 of the abdomen is longer, being almost as long as the width at its base.

Male.—Unknown.

Habitat.—South Queensland: Mount Tambourine, one female, in February; Blackall Range, one female, in January, A. P. Dodd.

Type.—In the Queensland Museum.

Paratype.—In the author's collection.

This may be the coastal form of *perspicuus,* or possibly a distinct species.

SCELIO FULGIDUS Crawford.

Proc. U. S. National Museum, Vol. 41, 1911.

Female.—Length, 3·5 mm.

Black; coxae dusky-black, the legs bright reddish-yellow; antennae black, the first two joints sometimes washed with red.

Head normal except that the vertex is broader and more transverse than usual; vertex smooth and shining, with scattered small punctures which are not denser toward the occiput; frons with similar punctures except that they are somewhat closer and denser; face above the antennal insertion not noticeably depressed, smooth, on either side with a very few punctures and with fine striae converging toward the mouth; cheeks without carinae, with dense punctures, toward the mouth smooth except for a few punctures; cheeks, occiput, and lower face with a pubescence of fine silky hairs; face and vertex without noticeable pubescence, but each puncture bears a very short fine seta. Antennae normal; scape as long as the next four or five joints combined; pedicel one-half longer than its greatest width; funicle 1 cupuliform, as long as the pedicel, 2 and the following transverse. Thorax from lateral aspect fully twice as long as high, the propodeum not declivous; from dorsal aspect two-thirds longer than its greatest width; pronotum coarsely rugose-punctate and with long white pubescence; parapsidal furrows consisting of a foveate row of large punctures, well-marked; a row of similar punctures against the anterior and lateral margins of the parapsides; parapsides smooth, except for a few scattered small punctures; anterior half or more of the median lobe of the scutum smooth, except for a very few minute punctures; posterior half of the median lobe with dense punctures of moderate size, arranged sub-confluently in five or six longitudinal rows; scutellum rather densely punctate, the punctures not large or confluent; scutum and scutellum with scattered long fine setae; postscutellum visible only as a thin line; propodeum rather long, its posterior angles rounded, densely rugose- or reticulate-punctate, at meson with indications of longitudinal carinae, laterally with white pubescence; mesopleurae finely punctate and longitudinally striate, but smooth ventro-anteriorly; metapleurae strongly rugose-punctate. Forewings normal; lightly smoky, the basal portion sub-hyaline; venation very pale and obscure. Abdomen hardly more than twice as long as its greatest width; segment 1 about as long as its width at base; 2 somewhat longer than 1; 3 a little yet distinctly longer than 2, fully twice as wide as long; 4 a little yet distinctly shorter than 3, rather less than one-half as long as the width at its posterior margin; 5 plainly shorter than 4, distinctly shorter than the width at its posterior margin; 6 much shorter than the width at its base; 1 strongly striate, and rugose between the striae; 2-5 very finely and densely striate except for the broadly smooth posterior margins; 6 rugose-punctate; 4-6 with scattered fine setae.

Male.—Antennae wholly black or piceous; coxae black, the femora piceous, the tibiae and tarsi yellow. Forewings hyaline. Vertex of head finely wrinkled or alutaceous; against the occiput finely transversely striate. Segment 3 of abdomen smooth laterally; 4 broadly smooth laterally and posteriorly; 5 and 6 wholly smooth, with a few scattered setae. Antennal scape rather short and stout, no longer than the next three joints combined; pedicel hardly longer than its greatest width; funicle 1 cupuliform, distinctly longer than the pedicel, one-half longer than its greatest width; 2 somewhat wider than long; 3 a little larger than 2 and perceptibly larger than 4, as wide as long; 4-7 much wider than long.

Habitat.—South Queensland; Toowoomba, a small series, H. Tryon; Roma, one female in November, A. P. Dodd. New South Wales; Pendennis and Singleton (type), W. W. Froggatt; Moree, three females in January, A. P. Dodd.

Type.—In the United States National Museum.

I have been permitted to examine part of the type series. A rather distinct species on account of the sculpture of the scutum.

This insect has been bred by Mr. Froggatt and Mr. Tryon from the eggs of the plague locust, *Chortoicetes terminifera* Walker.

SCELIO CHORTOICETES Froggatt.

Farmers' Bulletin No. 29, N. S. Wales Dept. of Agriculture, 1910, p. 34-35.

S. pulchellus Crawford, Proc. U.S. National Museum, Vol. 41, 1911.

Female.—Length, 3·75 mm.

Black; legs bright reddish-yellow, the coxae darker; antennae black, the first three or four joints clear reddish-yellow.

Head normal, the eyes rather smaller than usual; wholly smooth, except for rather numerous scattered small punctures bearing fine setae; occiput transversely striate; cheeks broader than usual. Antennae normal; scape long; pedicel almost twice as long as its greatest width; funicle 1 shorter than the pedicel, the remainder transverse. Thorax, from dorsal aspect, two-thirds longer than its greatest width; from lateral aspect, not much less than twice as long as high, the propodeum not declivous; pronotum coarsely rugose-punctate and with white pubescence; parapsidal furrows deep, broad, rugose; parapsides smooth, except for a few scattered small punctures; median lobe of scutum for its posterior three-fifths strongly reticulate-punctate, the anterior portion smooth but with numerous large shallow circular punctures; scutellum strongly reticulate-punctate; scutum and scutellum with scattered pubescence; postscutellum very transverse, its posterior margin straight; propodeum moderately long, its posterior angles truncate, densely finely punctate, at meson with a pair of carinae, on either side of which are several obscure sub-oblique rugae or carinae, laterally with white pubescence; mesopleurae strongly longitudinally striate; metapleurae rugose-punctate. Forewings lightly smoky, the basal portion paler; venation pale, indistinct, the stigmal spot small and not very distinct. Abdomen rather stout, two and a-third times as long as its greatest width; segment 1 hardly one-half as long as the width across its base; 2 almost twice as long as 1; 3 not much longer than 2, fully twice as wide as long; 4 hardly shorter than 3, hardly more than one-half as long as the width at its posterior margin; 5 two-thirds as long as 4, as long as the width at its posterior margin; 6 one-half as long as 5, shorter than its basal width; 1 rather strongly striate, rugose between the striae; 2 finely densely striate; 3 finely densely polygonally reticulate; 4 showing impressed reticulation which becomes indistinct posteriorly, the surface appearing almost smooth; 5 smooth, but showing faint reticulation; 6 rugose-punctate; 4 and 5 with a few setae which are denser on 6.

Male.—Unknown.

Habitat.—New South Wales: Lake Cowal, W. W. Froggatt.

Type.—In the collections of the Department of Agriculture, New South Wales.

A species without any close relations among the black forms. The sculpture of the median lobe of the scutum resembles that of *perspicuus,* but in that species the parapsides are densely sculptured, the head bears large dense punctures, the thorax is stout, and segments 3-5 of the abdomen are strongly striate. *Fulgidus* has a smooth anterior area on the scutum and the parapsides are smooth, but the punctuation of the posterior of the scutum and of the scutellum is quite different, and segments 3-5 of the abdomen are densely finely striate. *Chortoicetes* shows the closest affinity with the small red *concinnus,* but in the latter the smooth area of the scutum is much more extensive and the scutellum is irregularly longitudinally striate.

Mr. Froggatt bred this species from the eggs of the small plague locust, *Chortoicetes pusilla.*

S. pulchellus Crawford is a true synonym, and was described from part of the same material on which *chortoicetes* was based.

SCELIO CONCINNUS new species.

Female.—Length, 2·75 mm.

Head black; thorax rich orange-red, the scutellum and postscutellum contrasting dusky-black; abdomen dark brownish, black along its lateral margins; antennae black, the scape and pedicel orange-yellow, the next two joints suffused with yellow; legs wholly bright orange-yellow.

Head normal; vertex and frons smooth and polished, with a few scattered punctures of moderate size, the surface in some lights showing faintly alutaceous; toward occiput with fine transverse sub-circular striae and scattered long pubescence; cheeks narrow dorsally, broad ventrally, smooth and impunctate except for a few punctures and scattered pubescence dorsally. Antennae short; pedicel one-half longer than its greatest width; funicle 1 small, much smaller than the pedicel, a little longer than its greatest width, the remaining joints, except the last, transverse. Thorax from dorsal aspect a little less than twice as long as its greatest width; from lateral aspect about one-half longer than high, the propodeum not abruptly declivous; pronotum coarsely rugose-punctate and pubescent; parapsidal furrows well-marked and complete; median lobe of scutum for its posterior third reticulate-rugose, the anterior two-thirds smooth and polished except for a few irregular longitudinal striae; parapsides smooth, except for a few indefinite striae and punctures; scutellum strongly, irregularly, longitudinally striate, rugose laterally; postscutellum appearing at meson as a small feebly-bidentate plate; propodeum rather long, its posterior angles truncate, obliquely rugose-punctate, at meson with several longitudinal carinae or striae, without the usual lateral pubescence; mesopleurae densely longitudinally striate; metapleurae rugose. Forewings normal; lightly smoky, the basal portion pale yellowish; venation very pale and indistinct; a small distinct stigmal spot is present. Abdomen broadly ovate, no more than twice as long as its greatest width; segment 1 one-half as long as the width across its base; 2 twice as long as 1, and fully twice as wide as long; 3 hardly as long as 2; 4 a little yet distinctly shorter than 3; 5 plainly shorter than 4, and hardly one-half as long as the width at its posterior margin; 1 strongly densely striate; 2 more finely, very densely striate, the striae somewhat irregular; 3 finely densely reticulate, the reticulation raised for the major part but impressed laterally; 4 with obscure reticulation at base, smooth and shining for the rest; 5 and 6 smooth and shining.

Male.—Unknown.

Habitat.—South-west Queensland: Morven, one female in February, A. P. Dodd.

Type.—South Australian Museum, I. 16068.

This little species differs from all the red species in the sculpture of the scutum and scutellum. Of the black species, it resembles *chortoicetes* in the sculpture of the abdomen and the sparsely punctate head, but differs in colour, smaller size, more extensively smooth scutum, and the striate scutellum.

SCELIO ERYTHROPUS Dodd.

Trans. Ent. Soc. of London, 1919, p. 345.

Female.—Length, 4 mm.

Head and posterior half of abdomen black; thorax and basal half of abdomen orange; scutellum dusky; legs orange, also scape; pedicel fuscous, the next five or six joints black, the apical four or five joints pale yellow.

Head normal; with large punctures, these confluent on the frons, sub-confluent on the vertex; a few striae around the mouth; frontal depression short and narrow; eyes large, bare. Scutum confluently reticulate-punctate, also the scutellum; parapsidal furrows evident; propodeum rugose-punctate. Forewings reaching apex of abdomen; dusky; venation indistinct; stigmal spot distinct, covering the base of the stigmal vein. Abdomen about twice as long as its greatest width; segments all wider than long, 3 a little the longest; 1 striate and rugose between the striae, the rest rather finely densely striate and finely coriaceous between the striae; apex of 3, 4, and 5 with a semi-smooth narrow mesal area. Scape long and slender; funicle 1 longer than the pedicel and distinctly longer than its greatest width, the following joints all wider than long.

Male.—Unknown.

Habitat.—North Australia: Adelaide River, one female.

Type.—In the British Museum.

The type is unique. The species is peculiar on account of the pale yellow apical joints of the antennae, and the orange or red basal half of the abdomen contrasting with the black posterior portion.

SCELIO CRUENTATUS Dodd.

Proc. Royal Soc. of Queensland, Vol. XXVI., 1914, p. 112.

Female.—Length, 4·15 mm.

Bright red, the head black, the apical two abdominal segments dusky; legs wholly intense reddish-yellow; first four antennal joints testaceous, the remainder black.

Head normal; upper frons and vertex confluently reticulate-punctate, the punctures moderately large and shallow, and with a very short fine pale pubescence; toward occiput with several irregular transverse striae between which are indefinite punctures; antennal impression smooth, long and narrow, on either side broadly reticulate-punctate to the eye margins; against the mouth with very short striae; cheeks shallowly reticulate-punctate above, smooth toward the mouth except for large scattered punctures. Antennae normal; scape as long as the next five joints combined; pedicel twice as long as its greatest width; funicle 1 a little shorter and narrower than the pedicel; 2 and the following much wider than long. Thorax normal; from dorsal aspect, two-thirds longer than its greatest width; from lateral aspect, fully one-half longer than high, the propodeum not declivous; pronotum coarsely rugose- or reticulate-punctate; scutum strongly reticulate-punctate with a pronounced longitudinal arrangement, especially on the median lobe; parapsidal furrows deep, foveate, and complete; scutellum strongly longitudinally reticulate-punctate; postscutellar plate transverse, its posterior margin straight; propodeum moderately long, at meson with a pair of well-defined carinae, for the rest finely densely punctate in sub-oblique arrangement, the lateral patch of pubescence inconspicuous; mesopleurae strongly longitudinally striate. Forewings normal; deeply smoky, the basal third paler; venation very pale and indistinct, the stigmal vein and spot fuscous. Abdomen two and a-third times as long as its greatest width; segment 1 short, transverse; 2 two-thirds longer than 1; 3 plainly longer than 2, hardly twice as wide as long; 4 slightly shorter than 3, not much shorter than the width at its posterior margin; 5 a little shorter than 4, somewhat longer than the width at its posterior margin; 6 one-half as long as 5, as long as the width at its base; 1 strongly striate; 2 very densely, rather strongly striate; 3 very densely but more finely striate than 2, finely rugose between the striae; 4 and 5 rather densely finely striate, and without sculpture between the striae; 6 rugose-punctate.

Male.—Unknown.

Habitat.—North-west Queensland: Cloncurry, one female in April, A. P. Dodd.

Type.—South Australian Museum, I. 11019.

The type is unique. Of the red species, *cruentatus* is at once recognised from *nigricornis* by the absence of the conspicuous white pubescence on the head and thorax, and in having segment 3 of the abdomen striate instead of reticulate. From *fulvithorax,* it differs in the abdomen being red, the postscutellum not bidentate or concave, segment 3 of the abdomen being definitely striate, the punctuation of the scutum bearing a longitudinal arrangement, and in the reticulate punctuation of the frons. *Nigriscutellum* has the abdomen and postscutellum black, the apical abdominal segments shorter, the punctuation of the head is not reticulate, there are no definite transverse striae towards the occiput, the postscutellum is concave at meson, and segment 3 of the abdomen is reticulate medially.

Of the black species in which the first abdominal segment is transverse, *notabilis, amoenus,* and *nigrobrunneus* all differ in the stout type of thorax with declivous propodeum; the sculpture of the scutum is very different in *amoenus* and *notabilis; nigrobrunneus* differs in having no longitudinal arrangement of the sculpture of the scutum and scutellum, and the stronger irregular striae of segment 3 of the abdomen are very dissimilar from the fine regular striae of *cruentatus. Improcerus,* in which the thorax is not so stout while segment 1 of the abdomen is transverse, has the postscutellum concave, the punctuation of the head, scutum and scutellum not reticulate nor with a longitudinal arrangement on the scutum and scutellum.

SCELIO NIGRISCUTELLUM Dodd.

Trans. Royal Soc. of S. Aust., vol. xxxvii., 1913, p. 137.

S. melanogaster Dodd; Trans. Ent. Soc. of London, 1919, p. 347.

Female.—Length, 3 mm.

Head and abdomen black; thorax bright reddish-yellow, the scutellum and postscutellum dusky-black; legs, including the coxae, bright reddish-yellow; antennae black, the scape washed with red; mandibles red.

Head normal; frons and vertex with moderately large punctures, dense but not confluent; toward occiput confluent and arranged in subtransverse rows; confluent in longitudinal rows on either side of the antennal impression; cheeks broad, confluently rugose-punctate; each puncture bears a very fine, short seta, the head thus withous noticeable pubescence; mandibles long, acutely bidentate. Antennae normal; scape as long as the next five joints combined; pedicel rather slender, almost twice as long as its greatest width; funicle 1 cupuliform, rather distinctly shorter than the pedicel, the following joints transverse. Thorax from lateral aspect two-thirds longer than high, the propodeum not declivous; from dorsal aspect two-thirds longer than its greatest width; pronotum coarsely rugose-punctate and with rather stiff pale pubescence; scutum strongly rugose-punctate, with a distinct longitudinal tendency; parapsidal furrows deep and complete but somewhat obscured by the coarse sculpture; scutellum with similar but finer sculpture, the longitudinal arrangement pronounced; scutum and scutellum with scattered fine pubescence; postscutellum gently concave at the meson; propodeum long, its posterior angles truncate, with a pair of median carinae, its surface finely densely reticulate-punctate, the lateral patch of pubescence short and inconspicuous; meso- and metapleurae confluently longitudinally punctate and striate. Forewings lightly smoky, pale toward base; venation pale yellow, indistinct, the stigmal spot small and dark. Abdomen slightly more than twice as long as its greatest width; segment 1 short, more than three times as wide as the length at meson; 2 plainly longer than 1; 3 one-half longer than 2, somewhat less than twice as wide as long; 4 a little shorter than 3, less than one-half as long as the width at its posterior margin; 5 plainly shorter than 4, not greatly shorter than the width at its posterior margin; 6 one-half as long as 5, about one-half as long as its basal width, toward posterior margin with a margined border, the apex projecting just below this; 1 and 2 densely, rather finely striate, and finely rugose between the striae; 3 at meson finely reticulate-punctate, for the rest rather strongly striate but the reticulate sculpture is visible between the striae toward the medial area; 4 longitudinally striate, but the striae fail medially where the surface is opaque; 5 and 6 strongly striate.

Male.—Unknown.

Habitat.—North Queensland; exact locality unknown (type); Cairns district, one female in January; Mackay, one female in May.

Type.—South Australian Museum, I. 1369.

The type of *melanogaster* is in the British Museum.

Nigriscutellum was described from an imperfect specimen. A re-examination of the type, and of a third female, from Cairns, has established the fact that *melanogaster* is a true synonym.

This species closely resembles the bright forms of *nigricornis* in colour; in structure it agrees with the *nigricornis* group, embracing *nigricornis, pilosifrons,* and *contractus,* in the short first segment of the abdomen, and the reticulate sculpture of segment 3; however, it lacks the recumbent pubescence of the head of that group, and the reticulate area on segment 3 of the abdomen is quite restricted. Another character, small in itself but apparently valid, is the sharp incision of the lateral margin of the propodeum just before the posterior angle, so that the angle is prominent in the form of a blunt tooth; in *nigricornis, fulvithorax,* and their allied species, although the posterior angles of the propodeum are truncate, they are not prominent nor suggest the form of a tooth.

SCELIO NIGRISCUTELLUM PRETIOSUS new variety.

Female.—Differs from the typical form in that the punctures of the head are denser and confluent, and although the reticulation of segment 3 of the abdomen is distinct, the striae are present at the meson as well as laterally.

Habitat.—South Queensland: Chinchilla, one female in January, A. R. Taylor.

Type.—In the author's collection.

Only three specimens of the typical form have been seen, all from the coastal districts of North Queensland. Hence it is a little surprising to find the species in an inland district in Southern Queensland. When further specimens are known, from connecting localities, it will probably be found that the characters given for this variety do not hold, the two forms intergrading.

SCELIO FULVITHORAX new species.

Female.—Length, 3·5-4 mm.

Head and abdomen black; thorax rich orange-red, unmarked with black; legs wholly clear reddish-yellow; antennae black, the first three or four joints red.

Head normal; frons and cheeks with a pubescence of short silvery recumbent setae, this pubescence not as pronounced as in *nigricornis;* frons with large circular punctures, dense and sub-confluent, continued on either side of the rather long narrow antennal impression; punctures of vertex numerous but not dense, the surface between without sculpture; between the posterior ocelli and the occiput are strong, sub-transverse, sub-circular striae, between which are numerous large punctures; cheeks confluently punctate; mandibles long, bidentate, the teeth long and acute. Antennae normal; scape as long as the next five joints combined; pedicel scarcely twice as long as its greatest width; funicle 1 a little shorter than the pedicel, the following joints transverse. Thorax from lateral aspect two-thirds longer than high, the propodeum not declivous; from dorsal aspect almost twice as long as its greatest width; pronotum coarsely rugose-punctate, and with silvery pubescence; scutum confluently punctate, the punctures large, uneven in size, the sculpture tending toward rugose-punctate and with a slight longitudinal tendency; parapsidal furrows complete and broad but obscured by the sculpture; scutellum rather definitely longitudinally rugose-punctate; pubescence of scutum and scutellum fine and not conspicuous; postscutellum prominent, very distinctly concave at the meson; propodeum rather long, its posterior angles truncate, at meson with a pair of well-separated carinae, its surface sub-obliquely rugose-punctate, laterally with short fine pubescence; depressed area of mesopleurae rather strongly longitudinally striate, the surface between the striae indefinitely punctate; metapleurae strongly longitudinally rugose-punctate. Forewings normal; lightly smoky, paler at base; venation pallid, obscure, the stigmal spot small and dark. Abdomen about two and a-third times as long as its greatest width; segment 1 short, fully three times as wide as long; 2 distinctly longer than 1; 3 plainly longer than 2, almost twice as wide as long; 4 hardly shorter than 3, somewhat distinctly shorter than the width across its posterior margin; 5 rather distinctly shorter than 4, one-half as long as its width at the anterior margin, and about as long as the width at its posterior margin; 6 two-thirds as long as 5, a little shorter than its width at base; 1 strongly striate, and rugose between the striae; 2 densely striate, the striae somewhat wavy and irregular, the surface between finely sculptured; 3 for the most part densely polygonally reticulate, this sculpture giving way laterally and posteriorly to longitudinal striae; 4 rather strongly longitudinally striate, the striae straight, the surface between hardly sculptured; striae on 5 somewhat stronger and sparser than on 4; 6 longitudinally rugose-striate.

Male.—Unknown.

Habitat.—North Queensland: Kuranda, three females in March, F. P. Dodd.

Type.—South Australian Museum, I. 16075.

Paratypes.—In the author's collection.

This species comes near *nigricornis* and *nigriscutellum*, being in many respects intermediate between the two. From *nigricornis* it differs in the concave postscutellum, the sparser punctuation of the head, and the strong striae of segments 4 and 5 of the abdomen. From *nigriscutellum* it differs in the more pronounced pilosity of the head, the definite transverse striae toward the occiput, and the larger reticulate area on segment 3 of the abdomen.

SCELIO NIGRICORNIS Dodd.

Trans. Royal Soc. of S. Aust., vol. xxxvii., 1913, p. 136.

S. semisanguineus Girault, The Entomologist, London, July, 1914, p. 197.

S. semisanguineus var. *nigrocinctus* Dodd, Trans. Ent. Soc. of London, 1919, p. 346.

Female.—Length, 3-4 mm.

Head always black; thorax very variable in colour, from bright chestnut or orange-red unmarked with black to wholly black except that the pleurae and propodeum are more or less dark red; abdomen varying from wholly black except for traces of red on segments 2 and 3 to castaneous margined with black and with the two apical segments black; legs clear golden-yellow or red, the coxae sometimes dusky, the femora sometimes washed with brown; antennae black, the first four joints sometimes clear reddish-yellow or more or less dusky; mandibles red.

Head normal; with a very pronounced pubescence of stiff silvery recumbent setae, more conspicuous on the cheeks and frons; frons and vertex coarsely reticulate- or rugose-punctate; toward the occiput with sub-transverse striae, between which are shallow indefinite punctures; cheeks with large, shallow, confluent punctures; mouth without converging striae; mandibles long, acutely bidentate. Antennae normal; scape as long as the next four joints combined; pedicel twice as long as its greatest width; funicle 1 somewhat shorter than the pedicel, the following joints transverse. Thorax, from lateral aspect, one-half longer than high, the propodeum not abruptly declivous; from dorsal aspect, two-thirds longer than its greatest width; pronotum coarsely rugose-punctate, and with long, stiff, white pubescence; scutum and scutellum with scattered pubescence, strongly rugose- or reticulate-punctate with a more or less definite tendency toward longitudinal arrangement; parapsidal furrows deep, broad, and foveate; postscutellum showing as a transverse plate, its posterior margin feebly convex and emarginate; propodeum rather long, its posterior angles truncate, at meson with a pair of well-separated longitudinal carinae, its surface sub-obliquely, irregularly striate and finely rugose-punctate, laterally with silvery pubescence; mesopleurae rather strongly longitudinally striate; metapleurae longitudinally rugose-striate. Forewings lightly smoky, paler at base; venation pallid, obscure, the stigmal spot and stigmal vein dusky. Abdomen somewhat variable in length, from slightly more than twice as long as its greatest width to almost three times as long as wide; segment 1 short, fully three times as wide as long; 2 almost twice as long as 1; 3 plainly (about one-half) longer than 2, distinctly less than twice as wide as long; 4 a little shorter than 3, not greatly shorter than the width across its posterior margin; 5 somewhat shorter than 4, longer than the width across its posterior margin; 6 one-half as long as 5, as long as the width across its base; 1 rather strongly and somewhat irregularly striate, rugose between the striae; 2 densely striate, the striae somewhat wavy and irregular, the surface between finely rugose; 3 densely, finely, reticulate-punctate, without striae except toward extreme lateral margin; 4 either almost wholly reticulate or finely striate; 5 finely striate; 6 rugose-striate.

Male.—Body wholly black; antennae black; coxae black, the femora dusky, the tibiae and tarsi testaceous. Pubescence of head finer and less conspicuous than in the female; sculpture of head toward the occiput coarsely rugose-punctate with a transverse tendency but without distinct transverse striae. Forewings hyaline. Abdomen more slender than the thorax, of 8 visible segments; 3 almost twice as wide as long; 5 and 6 each plainly shorter than the width across the posterior margin; 7 and 8 short and transverse. Antennal scape as long as the next four joints combined; pedicel one-half longer than its greatest width; funicle 1 scarcely shorter than the pedicel, cupuliform; 2-7 plainly wider than long; 3 not perceptibly larger than 2 or 4.

Habitat.—Northern Territory: Darwin, G. F. Hill. Queensland: Mossman; Cairns; Atherton; Herbert River; Biggenden; Brisbane; Chinchilla; A. P. Dodd. New South Wales: Goondiwindi; Moree. South-west Australia: Yallingup, R. E. Turner. Three males, a large series of females.

Type.—South Australian Museum, I. 1368.

The type of *semisanguineus* is in the Queensland Museum, and that of *nigrocinctus* in the British Museum.

The species was originally described from the male sex. Girault founded *semisanguineus* on the typical bright-coloured form, from the Northern Territory. The variety *nigrocinctus,* from South-west Australia, can hardly be considered valid, seeing that the species is so variable in colour.

The three males I have seen, are all from the Cairns district. All the females in a series from North Queensland, and those from the Northern Territory, are of the bright-coloured form, with the thorax wholly red except that the scutellum is often dusky. Dark forms are encountered in Southern Queensland; a long series from Chinchilla is very variable in colour; in many the black on the thorax predominates, but there is always some red on the sides of the thorax. I have yet to see a wholly black female; on the other hand the three males are unmarked with red, and the black colouration is probably constant in this sex. It is evident that the species has a wide range.

SCELIO PILOSIFRONS new species.

Female.—Length, 3-4 mm.

Black; legs bright reddish-yellow, the coxae dusky-black; antennae black, the first three joints reddish-yellow.

Head normal; vertex and upper frons smooth and polished, with scattered rather small punctures, the surface very finely alutaceous or wrinkled; lower frons, and on either side of the antennal impression, with larger, denser punctures bearing stiff, silvery, recumbent pubescence; toward occiput rather finely transversely striate; cheeks with stiff silvery pubescence, with three rows of rather large, sub-confluent punctures separated by two obscure carinae. Antennae normal; scape as long as the next four or five joints combined; pedicel almost twice as long as its greatest width; funicle 1 somewhat distinctly shorter than the pedicel, cupuliform, one-third longer than its greatest width, the remaining joints transverse. Thorax rather stout; from dorsal aspect fully one-half longer than its greatest width; from lateral aspect rather less than one-half longer than deep, the propodeum not abruptly declivous; pronotum coarsely rugose-punctate and with stiff pubescence; scutum and scutellum with scattered setae, confluently punctate, the punctures large but not of regular size; parapsidal furrows deep, foveate, and complete; postscutellum rather prominent, bidentately concave at meson; propodeum moderately long, at meson with a pair of well-separated longitudinal carinae, the rest strongly obliquely striate or finely carinate and finely rugose between the striae, laterally with a narrow punctate pubescent area; meso- and metapleurae with stiff white pubescence along the anterior margins; depressed area of mesopleurae strongly longitudinally striate, the surface between the striae smooth and shining; metapleurae strongly rugose-punctate. Forewings lightly smoky, the basal portion paler; venation very pale and indistinct; a small dark stigmal spot is present. Abdomen hardly more than twice as long as its greatest width; segment 1 transverse, not one-half as long as the width across its base; 2 almost twice as long as 1; 3 very distinctly (about one-third) longer than 2, twice as wide as long; 4 a little shorter than 3; 5 somewhat but not greatly shorter than 4, as long as the width across its posterior margin; 6 rather long, as long as the width across its base; 1 strongly striate and rugose between the striae; 2 very densely, rather finely striate, the surface between polished and hardly sculptured; 3 with a dense sculpture of fine wavy or zigzag lines forming an intricate pattern, its lateral and posterior margins striate; 4 and 5 very finely, rather densely striate and with scattered fine hairs; 6 rugose-punctate.

Male.—Unknown.

Habitat.—South Queensland: Brisbane, two females in February; Chinchilla, six females in January. New South Wales: Moree, three females in October, January, and March; Goondiwindi, one female in December.

Type.—South Australian Museum, I. 16079.

Paratypes.—In the South Australian and Queensland Museums and the author's collection.

This species is related to *nigricornis*, but can be distinguished by the sparsely punctate head, and the peculiar pattern of the sculpture of segment 3 of the abdomen.

SCELIO CONTRACTUS new species.

Female.—Length, 2·75 mm.

Black; legs, including the coxae, wholly deep reddish-yellow; antennae black, the scape red, the next three joints dusky-reddish; mandibles red.

Head normal; frons and vertex strongly confluently reticulate-punctate, the punctures large, this sculpture continued on either side of the smooth frontal depression to the mouth; with short appressed silvery pubescence; toward occiput with several strong sub-transverse striae between which are shallow obscure punctures; cheeks with similar sculpture and pubescence to the frons. Antennae rather short; scape as long as the next five joints combined; pedicel two-thirds longer than its greatest width; funicle 1 somewhat shorter than the pedicel, cupuliform, one-third longer than its greatest width, the following joints transverse. Thorax rather stout; from dorsal aspect one-third longer than its greatest width; from lateral aspect one-half longer than high, the propodeum not abruptly declivous; pronotum short, rugose-punctate, with dense silvery pubescence; scutum coarsely rugose- or reticulate-punctate, with a faint tendency toward longitudinal arrangement, with scattered silvery pubescence; parapsidal furrows broad, shallow, rugose, obscured by the sculpture; scutellum with similar sculpture to the scutum, the longitudinal tendency more pronounced; postscutellum rather prominent as a transverse bidentately-concave plate; propodeum moderately long, its posterior angles truncate, sub-obliquely reticulate-punctate, at meson with a pair of straight carinae, the lateral patch of pubescence narrow; mesopleurae strongly longitudinally striate; metapleurae strongly reticulate-punctate. Forewings normal; lightly smoky, the basal portion paler; venation pale, obscure; a small dark stigmal spot is present. Abdomen hardly twice as long as its greatest width; segment 1 short and broad, several times as wide as its length at the median line; 2 longer than 1; 3 plainly longer than 2, fully twice as wide as long; 4 somewhat distinctly shorter than 3; 5 distinctly shorter than 4, shorter than the width across its posterior margin; 6 short; 1 striate, the surface between the striae finely rugose; 2, 4, and 5 finely striate, the surface between the striae smooth and polished; 3 finely densely reticulate, but striate toward its lateral margins; 6 rugose-punctate; abdomen without noticeable pubescence.

Male.—Coxae black, the legs bright reddish-yellow; antennae wholly black. Pubescence of head and thorax finer and not so conspicuous; sculpture of scutum and scutellum without a longitudinal tendency; no particular transverse striae are discernible toward the occiput where the surface is very strongly, transversely rugose-punctate; parapsidal furrows very broad, foveate, and well-marked. Forewings hyaline. Abdomen showing 8 segments, of which 7 and 8 are very short and transverse; stout, about twice as long as its greatest width; segment 4 slightly shorter than 3; 5 shorter than 4, hardly one-half as long as the width across its posterior margin; 3 finely polygonally reticulate; 4 finely striate and reticulate; 5 and 6 striate; 4-8 with dense fine pubescence.

Antennae black; the pedicel somewhat yellowish; scape rather short and stout; pedicel a little longer than its greatest width; funicle 1 a little larger than the pedicel, one-third longer than its greatest width; 2 rather distinctly wider than long; 3 very slightly longer but not perceptibly wider than 2 or 4; 2-7 each about one-half wider than long.

Habitat.—South Queensland: Chinchilla, seven females in January; Dulacca, two females in November; Morven, two females in February, one male in November; Goondiwindi, two females in December.

Type.—South Australian Museum, I. 16076.

Allotype.—In the author's collection.

Paratypes.—In the South Australian and Queensland Museums and the author's collection.

Closely related to *nigricornis* but differs in the concave postscutellum, stouter thorax, and stouter abdomen, segments 3, 4, and 5 being distinctly shorter in relation to their width than in that species; the male abdomen is much stouter than in *nigricornis.*

SCELIO IMPROCERUS new species.

Female.—Length, 3-3·5 mm.

Black; legs bright reddish-yellow, the coxae dusky-black; antennae black, the scape dark red and more or less dusky, the next two joints contrasting clear yellow, the fourth joint more or less yellowish.

Head normal; highly polished; vertex and frons with rather large, circular, confluent punctures; toward the occiput the punctures are arranged in irregular transverse rows; punctures continued on either side of the antennal impression, the mouth with short converging striae; cheeks confluently punctate like the frons; all punctures bear a fine seta but the pubescence is not conspicuous. Antennae stout; scape as long as the next five joints combined; pedicel one-third longer than its greatest width; funicle 1 cupuliform, as long as the pedicel, the remaining joints transverse. Thorax from dorsal aspect, two-thirds longer than its greatest width; from lateral aspect, one-half longer than high, the propodeum not abruptly declivous; pronotum coarsely rugose-punctate and with fine pubescence, the anterior-lateral angles minutely toothed; scutum and scutellum with rather large, circular, confluent punctures and fine inconspicuous pubescence, the punctures less dense on the lateral lobes of the scutum; parapsidal furrows deep and distinct, foveate; postscutellum prominent in the form of an upturned, transverse, bidentately-emarginate plate; propodeum moderately long, rather finely densely punctate, with white pubescence laterally, at the meson with two noticeable longitudinal carinae; depressed area of the mesopleurae strongly longitudinally striate, highly polished and impunctate between the striae; metapleurae longitudinally rugose-punctate. Forewings normal; lightly smoky, paler at base; venation pale, obscure; a small dark stigmal spot is present. Abdomen regularly ovate in outline; about

2¼ times as long as its greatest width; segment 1 much shorter than the width across its base; 2 distinctly longer than 1; 3 rather plainly longer than 2, more than twice as wide as long; 4 hardly shorter than 3; 5 a little yet distinctly shorter than 4, somewhat shorter than the width across its posterior margin; 6 two-thirds as long as 5; 1 strongly striate, and finely rugose between the striae; 2 densely striate, the surface between the striae polished and hardly sculptured; 3 densely striate, the striae very broken in outline especially toward the meson where there is a distinct tendency toward reticulation; 4 and 5 finely striate, the striae straight, the surface between faintly sculptured, the median line smooth and without striae; 6 rugose-punctate; 4-6 with scattered fine pubescence.

Male.—Coxae and femora black; antennae wholly black. Scape rather short; pedicel small, hardly longer than its greatest width; funicle 1 cupuliform, a little larger than the pedicel; 2-7 wider than long; 3 not perceptibly larger than 2 or 4. Agreeing with the female but the punctuation of the head is inclined to be reticulate- or rugose-punctate; striae on segments 4 and 5 of abdomen denser and more irregular, the meson of 4 and 5 not smooth, the surface between the striae finely sculptured. Abdomen with 8 visible segments, blunt at apex; 4 rather distinctly shorter than 3; 5 a little more than one-half as long as 4; 6 a little shorter than 5; 7 very transverse; 8 as a thin line; sides and apical third of abdomen with fine pubescence. Forewings sub-hyaline, the venation very pale yellow, the stigmal spot small.

Habitat.—South Queensland: Mt. Tambourine, one male, 12 females, in December and February, A. P. Dodd; Toowoomba, 3 females in March, L. F. Hitchcock; Blackall Range, one female in January.

Type.—South Australian Museum, I. 16077.

Allotype.—In the author's collection.

Paratypes.—In the South Australian Museum and Queensland Museum and the author's collection.

The colour of the scape varies, but is always considerably deeper than that of the pedicel.

This species is allied to *striatifacies, punctaticeps,* and *ignobilis,* but the thorax is not so slender, the postscutellum is definitely concave, the punctures of the head are considerably larger, and the striae on segment 3 of the abdomen are irregular. The male antennae differ from those of male *striatifacies,* in the shorter length of the funicle joint; in *striatifacies* funicle 3 is definitely larger than 2 or 4, and 2 and 3 are as long as wide; segments 4 and 5 of the abdomen in *striatifacies* are definitely longer.

SCELIO NIGROBRUNNEUS new species.

Female.—Length, 4 mm.

Black; segments 2 and 3 of abdomen dark reddish-brown, segment 4 suffused reddish dorsally; ventrally the abdomen is wholly deep reddish; legs, including the coxae, bright reddish-yellow, antennal scape fuscous, the next four joints deep reddish, the remaining joints black; mandibles red, their teeth black.

Head normal; upper frons and vertex with large circular confluent punctures bearing fine pale pubescence which is not conspicuous; against and in front of either lateral ocellus there is a small smooth area with a few minute punctures, or there may be a very narrow smooth path across the vertex between the lateral ocelli; toward the occiput the punctures are arranged in several ill-defined rugose rows; antennal impression rather large, impunctate, the face on either side with strong striae converging toward the mouth; cheeks confluently punctate dorsally, with several strong striae on the lower half; mandibles large, bidenate, the teeth strong and acute. Antennal scape moderately long and stout; pedicel two-thirds longer than its greatest width; funicle 1 cupuliform, a little shorter than the pedicel, the remaining joints transverse. Thorax from lateral aspect, not much longer than high; from dorsal aspect, one-half longer than its greatest width, the propodeum short; pronotum coarsely rugose-punctate and with noticeable long fine pubescence; scutum confluently punctate, the punctures large, circular, and shallow, and between the large punctures are small irregular ones, the sculpture with a reticulate tendency posteriorly; parapsidal furrows broad and rugose; scutellum coarsely reticulate-punctate; scutum and scutellum with a pubescence of very fine long setae; postscutellum prominent, transverse, rugose, its posterior margin gently convex; propodeum very short at meson, its posterior angles truncate, rugose, laterally with fine sub-oblique irregular striae and dense fine punctures, the lateral patch of pubescence narrow; mesopleurae strongly longitudinally striate; metapleurae strongly irregularly rugose-punctate. Forewings lightly smoky, paler at base; submarginal vein yellow, distinct, the stigmal vein deep fuscous and very conspicuous, the stigmal spot hardly marked. Abdomen scarcely more than twice as long as its greatest width; segment 1 short, transverse, one-third as long as its basal width; 2 almost twice as long as 1; 3 a little longer than 2, rather less than one-half as long as wide; 4 hardly shorter than 3, two-thirds as long as the width at its posterior margin; 5 a little shorter than 4, somewhat longer than its width at the posterior margin; 6 two-thirds as long as 5, as long as its basal width; 1 strongly striate and between the striae shallowly rugose; 2 finely very densely striate, and between the striae finely coriaceous; 3 more strongly striate than 2, the striae irregular and broken in outline, the surface between the striae quite strongly rugose; striae on 4 straight and more regular, the sculpture between finer, and there is a definite median stria; 5 rather sparsely strongly striate, the surface between hardly sculptured; 6 shallowly rugose-punctate and pubescent; lateral margins of 2-5 with large shallow indefinite punctures bearing long fine setae.

Male.—Unknown.

Habitat.—South Queensland: Chinchilla, one female in February. New South Wales: Moree, six females in January and March, A.P.D.

Type.—South Australian Museum, I. 16067.

Paratypes.—In the Queensland Museum and the author's collection.

The stout thorax, short propodeum, and transverse first abdominal segment among the species with the wholly striate abdomen and densely punctate scutum, ocur in *amoenus* and *notabilis.* In *amoenus* the scutum is highly polished and the punctures are not confluent, the post-scutellum is incised at the meson, the propodeum is more abruptly declivous from lateral aspect, the striae on segments 2-4 are much stronger, and the rugose sculpture on segment 3 is much stronger. In *notabilis* the forewings are stained yellowish, the striae on segments 3 and 4 of abdomen are sparse and very strong, and the scutum bears strong longitudinal striae or carinae. *Nigrobrunneus* approaches *orientalis* also, the sculpture of the thorax and of segment 3 of the abdomen being very similar, but in *orientalis* segment 1 is long, fully as long as its basal width, and the mesopleurae are not striate.

The colour of the abdomen is constant in all seven specimens, and is probably a valid specific character.

SCELIO NOTABILIS new species.

Female.—Length, 3·75 mm.

Black; legs, including the coxae, bright reddish-yellow; antennae black, the first three joints clear testaceous, the fourth suffused with yellow.

Head normal; highly polished; without conspicuous pubescence, but each puncture bears a very fine short seta; frons and vertex with numerous large circular punctures, dense but not confluent, toward the occiput arranged confluently in two or three sub-transverse rows; against the occiput with two strong sub-transverse carinae or striae; antennal impression broad, smooth, on either side with four or five strong striae converging to the mouth; cheeks with two strong central carinae, confluently punctate, the punctures large and shallow; mandibles bidentate, the teeth long and acute. Antennal scape as long as the next five joints combined; pedicel one-half longer than its greatest width; funicle 1 cupuliform, slightly shorter than the pedicel, 2 and the following transverse. Thorax stout; from lateral aspect as long as high, the propodeum abruptly declivous; from dorsal aspect a little longer than its greatest width; pronotum coarsely rugose and with blackish pubescence; parapsidal furrows not foveate, straight, almost parallel, obscured by the sculpture; median lobe of the scutum confluently punctate, the punctures very large, oval, with a rugose tendency and more or less longitudinally arranged, separated by several strong irregular longitudinal striae or carinae which are more or less obscure; parapsides with large confluent punctures with a rugose tendency; scutum with a pubescence of long rather stiff black hairs; scutellum strongly rugose- or reticulate-punctate, with a dense pubescence of stiff black setae; postscutellar plate prominent, transverse, rugose, with prominent posterior angles, its posterior margin uneven and faintly incised at the meson; propodeum rather short, its posterior angles truncate, at meson coarsely rugose-punctate and with a pair of median carinae, at base on either side with a small smooth shining area, laterally densely finely punctate and with dense white pubescence; depression of the mesopleurae smooth, shining, the area almost attaining the posterior margin, dorsad of this area with several very strong striae, anteriorly with strong punctures separated by three or four strong oblique striae, posteriorly with a row of small punctures; metapleurae coarsely longitudinally rugose-punctate. Forewings lightly yellowish, the base hardly paler; venation pale yellow, the stigmal spot pale but rather large. Abdomen hardly more than twice as long as its greatest width; segment 1 broad, less than one-half as long as its basal width; 2 a little longer than 1; 3 somewhat distinctly longer than 2, a little less than one-half as long as wide; 4 hardly shorter than 3, two-thirds as long as the width at its posterior margin; 5 very little shorter than 4, somewhat distinctly longer than the width at its posterior margin; 6 a little shorter than its width at the base; 1 strongly striate, rugose between the striae; 2 strongly striate; 3, 4, and 5 with very strong sparse striae, which are straight and regular, about 16 striae across 3, the surface between hardly sculptured; 6 densely punctate and pubescent; lateral margins of 2-5 with confluent large shallow punctures in longitudinal arrangement bearing fine setae.

Male.—Unknown.

Habitat.—North Queensland: Cairns district, seven females in May and June, A. P. Dodd.

Type.—South Australian Museum, I. 16073.

Paratypes.—In the South Australian and Queensland Museums and the author's collection.

The seven specimens were all collected on the ground in a small isolated patch of jungle, and the species has not been met with elsewhere.

The characters of this species are the stout thorax, peculiar sculpture of the scutum, the partially smooth mesopleurae, the black pubescence of the scutum and scutellum, the small smooth areas on the propodeum, the strongly sparsely striate abdomen, and the short first abdominal segment. It is rather nearly related to *amoenus,* but in that species the mesopleurae lack the smooth area, the scutum and scutellum bear a much finer pubescence, the parapsidal furrows are foveate, the scutum is uniformly punctate without longitudinal striae or carinae, the scutellum is confluently punctate without a rugose tendency, the forewings are smoky instead of yellowish, and the striae on the abdomen are more numerous, there being about 20 striae on segment 3.

SCELIO AMOENUS new species.

Female.—Length, 4·5 mm.

Black; legs, including the coxae, bright reddish-yellow; antennae black, the scape and pedicel clear reddish-yellow, the third joint deep reddish.

Head normal; frons and vertex highly polished, with large circular punctures, dense but not confluent; toward the occiput the punctures are large, confluent, and arranged in transverse rows; antennal impression broad and smooth, on either side with several strong striae converging to the mouth; cheeks with three rows of large confluent punctures, the central carinae not well defined; punctures of frons and cheeks bearing fine dark setae, the pubescence not conspicuous. Antennae normal; scape as long as the next five joints combined; pedicel about twice as long as its greatest width; funicle 1 slightly shorter than the pedicel, 2 and the following transverse. Thorax stout; viewed from the side, a little yet distinctly longer than high, the propodeum sharply declivous; from dorsal aspect one-third longer than its greatest width; pronotum strongly rugose-punctate, with long dark setae; scutum and scutellum highly polished; scutum with very large circular punctures, and at the median line with some smaller punctures, the punctures rather dense, not confluent, but the smaller punctures tend to join to form a few irregular longitudinal rows; parapsidal furrows wide apart, almost parallel, consisting of a row of large confluent punctures, failing by a little to reach the anterior margin; scutellum with large sub-confluent punctures, without a rugose tendency; scutum and scutellum with scattered long fine black hairs; postscutellar plate prominent, its posterior angles rounded, shortly concave at the meson; propodeum short, its posterior angles truncate, for the most part densely rather finely punctate and pubescent, at meson with four short longitudinal carinae; mesopleural depression densely punctate, the punctures moderate in size and arranged in longitudinal lines; metapleurae strongly rugose-punctate. Forewings deeply smoky, the basal portion paler; venation deep yellow and distinct, the stigmal vein fuscous, the stigmal spot dark. Abdomen $2\frac{1}{2}$ times as long as its greatest width; segment 1 short, less than one-half as long as its basal width; 2 a little longer than 1; 3 almost one-half longer than 2, twice as wide as long; 4 hardly shorter than 3, not much shorter than the width at its posterior margin; 5 slightly shorter than 4, very distinctly (about two-fifths) longer than the width at its posterior margin; 6 about as long as the width at its base; 1 strongly striate, rugose-punctate between the striae; 2 strongly striate, the striae somewhat curved and irregular, the surface between finely sculptured; 3 with about 20 strong striae, its basal two-thirds rather strongly rugose-punctate also, causing the striae to become wavy and very broken in outline; 4 and 5 very strongly striate, the striae regular; 5 with rather large shallow punctures between the striae; 6 densely punctate and pubescent.

Male.—Unknown.

Habitat.—South Queensland: Blackall Range, one female in February, A. P. Dodd.

Type.—South Australian Museum, I. 16072.

The differences between this form and *notabilis* have been pointed out in the discussion of the characters of the latter species. The abdomen is of the same shape in both species, but in *notabilis* the striae on segment 3 are regular and no rugose-punctuation is discernible. The thorax in *amoenus* is less stout.

SCELIO ORIENTALIS Dodd.

Archiv fur Naturgeschichte, Berlin, Vol. 80, 1915.

Female.—Length, 3·75-4 mm.

Black; legs, including coxae, bright reddish-yellow; antennae black, the scape reddish-yellow, the pedicel and funicle 1 more or less reddish.

Head normal; upper frons and vertex with large dense or subconfluent punctures, and with an inconspicuous pubescence of very fine pale hairs; punctures of frons with a tendency toward longitudinal arrangement; toward the occiput the punctures are confluent and arranged in irregular transverse rows; between the lateral ocelli is a transverse area, smooth except for a few punctures; antennal impression not large, the face on either side with several strong striae converging toward the mouth; cheeks with the usual three or four carinae or striae, between these confluently rugose-punctate; mandibles bidentate, the teeth acute and moderately long. Antennae normal; scape as long as the next five joints combined; pedicel one-half longer than its greatest width; funicle 1 cupuliform, a little longer than the pedicel, 2 and the following joints wider than long. Thorax from lateral aspect one-third longer than high, the propodeum rather abruptly declivous; from dorsal aspect hardly one-half longer than its greatest width; pronotum strongly rugose-punctate and with fine pale pubescence; scutum with large circular confluent punctures; parapsidal furrows rugose, complete but obscure; scutellum with large confluent punctures with a tendency toward reticulate arrangement; scutum and scutellum with a pubescence of very fine pale hairs; postscutellum not prominent, rugose, its posterior margin gently convex; propodeum short, its posterior angles truncate, laterally with rather small confluent punctures and dense silvery pubescence, at meson with large punctures and several short obscure carinae; mesopleurae with rather small subconfluent punctures arranged longitudinally; metapleurae with rather small dense punctures centrally, strongly rugose-punctate dorsally and ventrally. Forewings rather darkly smoky, the basal portion yellowish; venation very distinct, the submarginal vein dark yellow, the stigmal vein fuscous, the stigmal spot small and dark. Abdomen 2½ times as long as its greatest width; segment 1 as long or a little longer than its basal width; 2 not much longer than 1; 3 somewhat distinctly longer than 2, fully twice as wide as long; 4 hardly shorter than 3, three-fifths as long as the width at its posterior margin; 5 somewhat shorter than 4, not or hardly longer than the width at its posterior margin; 6 as long as the width at its base; 1 strongly striate, between the striae rather strongly rugose; 2-5 highly polished; 2 strongly striate, faintly sculptured between the striae; 3 strongly striate, the striae inclined to be wavy and broken in outline, the surface between definitely rugose; striae strong and straight on 4 and 5, sparser on 5, the surface between finely granulate; striae failing at the median line of 4 and posterior third of 3; 6 rugose-punctate and pubescent; basal depression of segment 2 with raised lateral angles.

Male.—Coloured like the female except that the antennae are wholly black. Head, scutum and scutellum confluently punctate with a reticulate tendency; striae on segments 3-5 of abdomen finer than in the female. Abdomen blunt at apex; segment 5 hardly more than one-half as long as the width at its posterior margin; 6 transverse; 7 very short; 4-6 with a pubescence of short fine hairs. Antennal scape rather short; pedicel hardly longer than its greatest width; funicle 1 one-third longer than the pedicel; 2 somewhat wider than long; 3 slightly wider and distinctly longer than 2, a little longer than wide; 4-7 quadrate, each a little shorter than 3.

Habitat.—Queensland: Cairns district, one male (type) in February, one female in January; Rockhampton, one male in February; Blackall Range, three females, one male, in February, A. P. Dodd.

Type.—South Australian Museum, I. 11088.

In the Cairns female, the punctures on the frons are less dense, the irregular blunt carinae more conspicuous. A jungle species.

Notabilis and *amoenus* resemble *orientalis* in the stout thorax and large punctures of the head, scutum and scutellum, but differ in the short first segment of the abdomen, the emarginate postscutellum, and the punctuation of the scutum is different. *Nigrobrunneus,* another species with stout thorax and large punctures of the head and thorax, also has the first segment of the abdomen short, and the mesopleurae are striate. In *striatifacies, punctaticeps, ignobilis,* and their relations, the thorax is of a more slender type, and the punctures of head and thorax are small. In *asperatus,* the punctuation of the scutum is very definitely reticulate.

SCELIO FLAVICORNIS Dodd.

Trans. Royal Soc. of S. Australia, Vol. xxxvii., 1913, p. 136.

S. pilosus Dodd, ibidem, p. 137.

S. pilosiceps Dodd, Proc. Royal Soc. of Q'land, Vol. xxvi., 1914, p. 116.

S. locustae Dodd, ibidem, p. 117.

S. perplexus Dodd, ibidem, p. 117.

Female.—Length, 3·4-4·8 mm.

Black; coxae black, the legs bright red or dark red, the femora sometimes piceous; antennae black, the first three joints sometimes washed with brown; mandibles very deep red.

Head normal; vertex rather finely densely reticulate-punctate; toward the occiput with open reticulation arranged transversely; upper frons with strong sparse irregular longitudinal striae, the surface between definitely rugose-punctate or almost smooth; lower frons regularly striate, the surface between smooth; antennal impression narrow and smooth; cheeks broad, densely rugose-punctate; frons and cheeks with a very conspicuous pubescence of stiff silvery-white hairs, the hairs finer and less conspicuous on the vertex. Antennae normal; scape slender, fully as long as the next five joints combined; pedicel one-half longer than its greatest width; funicle 1 cupuliform, a little longer and wider than the pedicel, 2 and the following transverse. Thorax stout; from lateral aspect one-third to one-half longer than high, the propodeum sloping; from dorsal aspect one-third to one-half longer than its greatest width; pronotum and anterior margin of meso- and metapleurae with a pubescence of stiff silvery hairs, which are scattered over the scutum, but the scutellum bears fine pubescence; pronotum coarsely reticulate-punctate; scutum and scutellum reticulate- or rugose-punctate, coarse or shallow, with a slight or very decided tendency toward longitudinal arrangement; parapsidal furrows not evident; postscutellum very transverse, its posterior margin feebly convex; propodeum moderately short, its posterior angles rounded, densely rather finely reticulate-punctate, at meson with several strong striae or carinae, against lateral margins with fine pubescence, and toward posterior angles with stiff white pubescence; mesopleurae finely longitudinally striate and densely finely punctate; metapleurae rather finely reticulate-punctate, but with coarser sculpture anteriorly. Forewings smoky, the basal portion subhyaline; venation pale yellow, indistinct, the stigmal vein fuscous, the stigmal spot obscure. Abdomen two to three times as long as its greatest width; segment 1 shorter than the width across its base; 2 not much longer than 1; 3 one-half longer than 2, twice as wide as long; 4 as long as 3, a little to one-half shorter than the width at its posterior margin; 5 somewhat shorter than 4, longer than the width at its posterior margin; 6 hardly one-half as long as 5; 1 strongly striate, finely or strongly rugose between the striae; 2 densely striate, and finely granulate between, the sculpture sometimes subobsolete except laterally; 3 finely striate and granulate between the striae which sometimes fail at the meson, or strongly striate, the striae for the anterior half broken and irregular, and definitely rugose between; 4 and 5 finely striate and finely granulate between the striae which sometimes fail at the meson of 4; 6 rugose-punctate; sides of abdomen and segments 5 and 6 with scattered stiff white hairs; lateral angles of groove at base of segment 2 with raised margins.

Male.—Striae on upper frons less distinct, the sculpture appearing longitudinally reticulate-punctate; pubescence of head and thorax rather finer than in the female; segments 2-6 of abdomen rather finely striate and granulate between the striae which sometimes fail at the meson. Antennae tawny-yellow, the scape piceous; scape stout and rather short; pedicel a little longer than its greatest width; funicle 1 cupuliform, distinctly longer than the pedicel, one-third longer than its greatest width; 2 somewhat wider than long; 3 scarcely larger than 2 or 4, somewhat wider than long; 4-7 subequal, each somewhat wider than long.

Habitat.—Queensland: Cairns district, 0-2,500 feet, a small series in February and March; Herbert River, one pair in March; Brisbane, a series in November-April. New South Wales: Clarence River, one female in May.

Type.—South Australian Museum, I. 1367.

This species is variable in respect to size, stoutness of the thorax and abdomen, and coarseness of the sculpture. It is difficult to reconcile the robust, broad abdomened, coarsely sculptured forms with the small, slender, finely sculptured specimens, but they appear to intergrade; it is possible, however, that more than one species is represented in the series.

Unfortunately, I have described the species under five different names and am now glad to establish the synonymy. *Flavicornis* was described from the Cairns district, and is a male with hyaline wings, and the striae failing medially on segments 2 and 3 of the abdomen. *Perplexus,* described from the Herbert River, appears to be the common form of the male in which the abdominal segments are uniformly striate and the wings are not hyaline; in my collection are further males from Cairns and Brisbane. The type specimen of *pilosus,* from the Cairns district, represents the typical female, midway in size and coarseness of sculpture between the robust and slender forms; the type of *pilosiceps*, from the Clarence River, is of this form, to which most of the females from Brisbane and from the Atherton Tableland belong. *Locustae,* described from the Herbert River, is a small specimen with dark femora and very fine sculpture; I have a similar female from Brisbane. Most of the females from the lowlands of the Cairns district are very robust and coarse in sculpture, and one or two from Brisbane tend toward this form. This is seemingly the most abundant species in the vicinity of Brisbane.

The species is characterised by the striae on the upper frons in the female. The stiff silvery pubescence of the head is another feature, which is found to a lesser extent in *bipartitus* and the species of the *nigricornis* group. The male may be distinguished from that of *bipartitus* in the stouter abdomen, shorter first abdominal segment, rounded propodeal angles, and in funicle 3 of the antennae being very little larger than 2 or 4.

SCELIO BIPARTITUS Kieffer.

Berlin Ent. Zeitschr., Vol. 51, 1907, p. 296.

S. australis Froggatt, Bull. No. 29, N.S.W. Dept. of Agric., 1910, pp. 34-35.

S. froggatti Crawford, Proc. U. S. National Museum, Vol. 41, 1911.

S. ovi Girault, Proc. Ent. Soc. of Washington, Vol. xv., 1913, p. 4.

S. affinis Dodd, Proc. Royal Soc. of Q'land, Vol. xxvi., 1914, p. 116.

Female.—Length, 3·5-5 mm.

Black; legs, including the coxae, bright reddish-yellow, the coxae rarely brown; antennae black, the scape often yellow, the next two joints sometimes yellowish; mandibles red.

Head normal; cheeks and frons with a conspicuous pubescence of moderately-fine silvery-white hairs, which are finer and less noticeable on the vertex; frons and vertex varying from confluently punctate with a slight reticulate tendency to very definitely reticulate- or rugose-punctate, the punctures large and deep, rarely rather fine and shallow on the vertex; toward the occiput the sculpture is arranged transversely; antennal impression moderately small, smooth, the face on either side with striae converging toward the mouth, but often the large punctures of the upper frons continue for some distance; cheeks rather broad, with large confluent punctures, more or less reticulate; mandibles strongly bidentate. Antennae normal; scape as long as the next five joints combined; pedicel almost twice as long as its greatest width; funicle 1 cupuliform, slightly longer than the pedicel, 2 and the following transverse. Thorax, from lateral aspect, one-half to two-thirds longer than high, the propodeum sloping; from dorsal aspect, about two-thirds longer than its greatest width; pronotum coarsely rugose-punctate and with dense silvery pubescence; scutum and scutellum with scattered pubescence, strongly reticulate-punctate; parapsidal furrows consisting of a row of rugose punctures, complete but obscured by the sculpture; post-scutellum transverse, rugose, not prominent, its posterior margin almost straight; propodeum rather short at meson, long laterally, its lateral margins converging, its posterior angles truncate, at meson with 4-6 striae or carinae of which the median pair is very distinct, the surface between rugose-sulcate, for the rest densely finely pubescent and rather finely densely punctate; mesopleurae rather finely densely subconfluently punctate, arranged in longitudinal rows; metapleurae more strongly confluently punctate with an irregular longitudinal tendency. Forewings normal; smoky, the basal portion subhyaline; venation pale yellow, the stigmal vein and spot brown. Abdomen regularly fusiform, slender, three times as long as its greatest width; segment 1 as long or a little shorter than its basal width; 2 rather distinctly longer than 1; 3 plainly (about one-third) longer than 2, from three-fourths to almost as long as its greatest width; 4 a little shorter than 3, as long as the width at its posterior margin; 5 a little shorter than 4, plainly longer than the width at its posterior margin; 6 one-half as long as 5, as long or longer than its basal width; 1 strongly striate, rugose between the striae; 2 less strongly striate than 1, but more strongly so than 3 or 4; 3-5 densely striate, the striae regular and straight except at the meson of 3, between the striae granulate, this sculpture stronger at the meson of 3; 3 and 4 with a smooth posterior path which is broadest at the meson; 6 rugose-punctate and pubescent.

Male.—Hardly differing from the female except in sexual characters; the striae on the abdominal segments are rather sparser and may fail narrowly at the median line of 5; segments 4-5 with scattered short fine pubescence, whch is denser on 6.

Antennae somewhat variable in colour, sometimes almost wholly clear testaceous, or piceous at base gradually verging to testaceous; scape short and stout, rather shorter than the next four joints combined; pedicel no longer than its greatest width; funicle 1 distinctly longer than the pedicel, one-half longer than its greatest width; 2 as wide as long; 3 distinctly larger than 2 or 4, as long as wide; 4-7 each distinctly wider than long.

Habitat.—Northern Territory: Darwin. Queensland: Mossman, Cairns, Kuranda, Atherton, Innisfail, Herbert River, Mackay, Childers, Blackall Range, Brisbane, Mount Tambourine, Chinchilla. New South Wales: Tweed and Clarence Rivers.

Type.—In the British Museum.

The type of *australis* is in the New South Wales Department of Agriculture; that of *froggatti* in the United States National Museum; that of *ovi* in the Queensland Museum; and that of *affinis* in the South Australian Museum.

Kieffer described this species from a male from Mackay, Queensland. Some years ago, the writer examined the type in the British Museum, and made descriptive notes, from which he is able to deduce that the common species of Eastern Australia which has gone under the name of *australis* Froggatt, is a synonym of Kieffer's species.

I have already stated that *froggatti* is a synonym of *australis,* and, in my opinion, *ovi* should fall also. The character of the yellow antennal scape can hardly be considered valid, and the differences in venation, noted by Girault, would not appear to be of much value. It is significant that both *ovi* and *australis* are taken in company in almost every district and are both parasitic on the eggs of *Locusta danica* and *L. australis.*

The type of *affinis* Dodd is a male in which the apical antennal joints are darker than usual, but otherwise it agrees with typical males.

Bipartitus is a very common form in the coastal districts of Queensland; it has been taken in one inland locality, Chinchilla, where it is apparently rare. Both the known hosts are rather definitely restricted to the coast, and are not inland insects.

There is considerable variation in size, and, to a lesser extent, in the coarseness of the sculpture. A peculiar female from the Blackall Range shows segments 4 and 5 of the abdomen smooth and without striae except laterally, the suture between 4 and 5 is obliterated medially, and there is a sharply-excised row of small foveæ near the base of 4.

Of the females that might be confused with *bipartitus, asperatus* may be recognised by the absence of conspicuous pubescence on the head, the smaller non-confluent punctures of the frons, and the shallow more open reticulation of the scutum. *Striatifacies, punctaticeps, ignobilis, diemenensis,* and *improcerus* differ in the lack of conspicuous pubescence on the head, and the small punctures of the head and thorax. *Orientalis* differs in the absence of the conspicuous silvery pubescence, the declivous propodeum, shining appearance, &c. In *flavicornis*, the pubescence of the head is still coarser, and the frons is longitudinally striate. In the male sex, *bipartitus* differs from most of the species in having the antennae not wholly black, and the abdomen being slender.

SCELIO ASPERATUS new species.

Female.—Length, 3·5-4·8 mm.

Black, the abdomen sometimes washed with deep brown; legs, including the coxae, bright golden-yellow; antennae black, the scape and pedicel sometimes suffused with red.

Head normal; toward the occiput strongly transversely rugose-punctate; vertex between the ocelli smooth, with rather numerous scattered punctures of moderate size; frons with dense punctures of moderate size and subconfluent; on either side of the smooth antennal impression without punctures, with sparse striae converging toward the mouth; cheeks coarsely shallowly rugose-punctate and with two strong central carinae; pubescence of head very fine and inconspicuous, that of the cheeks longer. Antennal scape as long as the next four joints combined; pedicel one-half longer than its greatest width; funicle 1 cupuliform, slightly longer than the pedicel, two-thirds longer than its greatest width, 2 and the following transverse. Thorax from lateral aspect two-thirds longer than high, the propodeum not declivous; from dorsal aspect one-half longer than its greatest width; pronotum coarsely rugose-punctate, with rather long setae; scutum and scutellum with scattered fine setae, very strongly rugose- or reticulate-punctate, the punctures very large except at the median line of the scutum; parapsidal furrows rather deep and broad but obscured by the sculpture; post-scutellum showing as a straight very transverse plate; propodeum moderately long, its posterior angles truncate, rather finely rugose-punctate, at meson with several obscure longitudinal carinae of which the median pair is rather well defined, laterally with white pubescence; mesopleurae longitudinally striate, between the striae finely punctate; metapleurae longitudinally striate and more definitely punctate. Fore-wings lightly smoky, the base paler; venation pale yellow but distinct, the stigmal spot small and dark. Abdomen $2\frac{1}{2}$ times as long as its greatest width; segment 1 about as long as the width at its base; 2 plainly longer than 1; 3 a little longer than 2, twice as wide as long; 4 as long as 3, not much shorter than the width at its posterior margin; 5 distinctly shorter than 4, fully as long as the width at its posterior margin; 6 fully as long as its width at base; 1 strongly striate, finely rugose between the striae; 2-5 rather finely densely striate, the striae straight and regular, failing rather narrowly at the median line of 3, 4, and 5; between the striae coriaceous, this sculpture stronger on 3, so that where the striae fail at the meson, the sculpture is finely reticulate; 6 rugose-punctate.

Male.—Coxae dusky-black, the legs bright reddish-yellow; antennae wholly dusky-black. Frons and vertex of head strongly rugose-punctate, toward the occiput with a transverse tendency, striate on either side of the antennal impression. Thorax from lateral aspect stouter, less than two-thirds longer than high; parapsidal furrows well marked. Forewings tinted as in the female. Abdomen with segments 2-5 without noticeable sculpture between the striae; 3, 4, and 5 smooth at the median line; 4-6 with a conspicuous pubescence of long fine setae; 5 somewhat shorter than the width at its posterior margin; 6 hardly as long as the width at its posterior margin; 7 and 8 very short, transverse. Antennal scape hardly as long as the next four joints combined; pedicel small, slightly longer than its greatest width; funicle 1 considerably larger than the pedicel, one-third longer than its greatest width; 2 wider than long; 3 a little wider than 2, plainly larger than 4, slightly wider than long; 4-7 much wider than long.

Habitat.—South Queensland: Brisbane, one pair in November; Mount Tambourine, one female, five males, in February; Blackall Range, one female in February; Chinchilla, two females in January; Morven, one female in February. New South Wales: Moree, two females in March.

Type.—South Australian Museum, I. 16074.

Allotype.—In the South Australian Museum.

Paratypes.—In the Queensland Museum and the author's collection.

A somewhat variable species in regard to size and stoutness. A very large female from the Blackall Range has the abdomen three times as long as its greatest width, the segments relatively longer, and the sculpture between the striae on segment 3 is coarser. A rather large example from Morven has a stouter thorax, and very stout abdomen which is no more than twice as long as its greatest width, while the sculpture between the striae on the segments is very fine.

A female from the Atherton tableland, North Queensland, taken in March, differs in that the wings are yellowish instead of smoky, and the punctures on the frons are sparser.

In the female, *asperatus* differs from *punctaticeps* and related forms, and approaches *bipartitus*, in having the scutum and scutellum coarsely reticulate-punctate; however, in *bipartitus* there is a conspicuous pubescense on the head, and the sculpture of the head is coarser and denser, being reticulate-punctate.

SCELIO PARVICORNIS Dodd.

Proc. Royal Soc. of Q'land, vol. xxvi., 1914, p. 113.

Female.—Length, 3·75 mm.

Black; legs reddish-yellow, the coxae dusky-black, the femora dusky; antennae wholly black.

Head normal; vertex and upper frons smooth, with numerous scattered punctures of moderate size, each bearing a very fine and short seta; toward the occiput with faint transverse striae; lower frons with rather dense striae converging toward the mouth, the antennal impression moderately large and smooth; cheeks with a few punctures.

Antennae short; scape stout, as long as the next five joints combined; pedicel one-half longer than its greatest width; funicle 1 a little yet distinctly shorter and narrower than the pedicel; 2-4 very transverse, the club joints very transverse. Thorax slender; from lateral aspect about twice as long as high, the propodeum not abruptly declivous; from dorsal aspect almost twice as long as its greatest width; pronotum coarsely rugose-punctate and pubescent; scutum confluently punctate, the punctures of moderate size, with a reticulate tendency, and on the median lobe with a decided tendency toward arrangement in longitudinal lines; parapsidal furrows broad, deep, and foveate; scutellum confluently punctate, with a slight reticulate tendency; postscutellum very short, transverse, not bidentate or conspicuous; propodeum moderately long, densely finely punctate in suboblique rows, at meson with several more or less obscure carinae. Forewings normal; lightly cloudy, the basal portion subhyaline; venation pale and indistinct, the stigmal spot hardly marked. Abdomen $2\frac{1}{2}$ times as long as its greatest width; segment 1 a little shorter than the width across its base; 3 rather distinctly longer than 2, twice as wide as long; 4 a little shorter than 3, about three-fifths as long as the width at its posterior margin; 5 not much shorter than 4, hardly as long as the width at its posterior margin; 1 strongly striate, and rugose between the striae; 2 rather finely and densely striate; 3 finely striate, and granulate between the striae which fail rather broadly at the median line; 4 and 5 broadly smooth at the meson, for the rest finely striate; 6 rugose-punctate.

Male.—Unknown.

Habitat.—South Australia (exact locality unknown).

Type.—Macleay Museum, Hy. 4D.

The type is unique. This species belongs to the *punctaticeps* group, of which, on account of the sparse punctuation of the head, its closest affinity is with *diemenensis.* However, the punctures on the head are less sparse in that species, the parapsidal furrows are not deep and broad, the punctuation of the scutum has no reticulate or rugose tendency, and the striae on segments 3-5 of the abdomen are more numerous.

SCELIO STRIATIFACIES Dodd.

Proc. of Royal Soc. of Queensland, Vol. xxvi., 1914, p. 115.

Female.—Length, 3·5-4·25 mm.

Black; antennae wholly black; legs bright reddish-yellow, the coxae black.

Head normal; vertex and frons not polished but finely coriaceous or granulate, with dense punctures of moderate size which are not confluent; punctures confluent toward the occiput and arranged in transverse rows; between the ocelli a very few punctures only are present; cheeks confluently punctate; face on either side of antennal depression with striae converging toward the mouth; head without noticeable pubescence except for fine setae on the cheeks and lower face.

Antennae as in *punctaticeps.* Thorax from lateral aspect almost twice as long as high, the propodeum not declivous; from dorsal aspect almost twice as long as its greatest width; pronotum coarsely rugose-punctate and with long white setae; scutum confluently punctate, the punctures moderately large and somewhat uneven in size, with a tendency toward longitudinal arrangement; scutellum confluently punctate; postscutellum not conspicuous, as a very transverse plate; propodeum long, its posterior angles truncate, sculptured as in *punctaticeps* but of the central carinae the median pair only are well marked; mesopleurae for the most part longitudinally striate and confluently punctate; metapleurae densely punctate. Forewings normal; smoky, the basal portion yellowish; venation pale yellow, indistinct, the stigmal spot small and distinct. Abdomen not as slender as in *punctaticeps,* tapering more abruptly from the posterior margin of segment 3; rather less than $2\frac{1}{2}$ times as long as its greatest width; segment 1 a little shorter than the width across its base; 2 one-half longer than 1; 3 slightly longer than 2, twice as wide as long; 4 slightly shorter than 3, very distinctly shorter than the width across its posterior margin; 5 a little more than one-half as long as 4, not or scarcely longer than the width across its posterior margin; 6 hardly one-half as long as 5; 1 strongly striate and rugose between the striae; 2-5 finely densely striate, the striae not as regular as in *punctaticeps* and failing narrowly at the median line of segments 4 and 5, the surface between the striae finely granulate; pubescence on apical segments much as in *punctaticeps.*

Male.—Agreeing with the female but the femora are piceous; the punctures on the head, although not larger, are denser, being subconfluent on the frons and forming rugose-punctuation on the vertex; the punctures are continued on either side of the antennal depression where there are no distinct striae; the sculpture of the thorax is similar to that of the female; the parapsidal furrows are very deep and broad; the striation of the abdomen is similar but the striae fail rather broadly at the meson of segments 4 and 5 and less so on 3; 6 rugose-striate, smooth medially; 3-6 with scattered pin-punctures and some pubescence. Antennae black, the pedicel suffused with yellow; pedicel small, no longer than wide; funicle 1 cupuliform, almost one-half longer than its greatest width; 2 slightly shorter than 1, but fully as long as its greatest width; 3 a little widened, no wider than long; 4-7 not very much wider than long.

Habitat.—South Queensland: Mount Tambourine, 2,000 feet, two females in February; Brisbane, two males in November; Blackall Range, one female in February; Chinchilla, one female in February. New South Wales: Clarence River, one female (type) in June.

Type.—South Australian Museum, I. 11021.

Very closely related to *punctaticeps,* but the abdomen is stouter, the segments uniformly shorter, the parapsidal furrows are well marked, the upper frons and vertex of the head bear fine granulate sculpture as well as the punctures, and the mesopleurae are confluently punctate and more or less distinctly striate.

SCELIO PUNCTATICEPS Dodd.

Archiv fur Naturgeschechte, Berlin, 79, 1914, p. 77.

S. nigricoxa Dodd, ibidem, p. 78.

Female.—Length, 3-4 mm.

Black; legs, including the coxae, bright reddish-yellow; antennae black, the scape and sometimes the pedicel reddish-yellow; tegulae black.

Head normal; vertex and frons polished, with dense punctures of moderate size which are not confluent; a transverse area between the ocelli smooth and almost devoid of punctures; toward the occiput the punctures are subconfluent with a tendency toward arrangement in transverse rows; on either side of antennal depression with striae converging toward the mouth; cheeks with dense punctures; each puncture bears a very fine, short seta, the pubescence not conspicuous, that of the cheeks longer. Antennae normal; scape as long as the next four or five joints combined; funicle 1 cupuliform, slightly longer than the pedicel, one-third longer than its greatest width, the remaining joints, except the last, twice as wide as long. Thorax normal; rather slender; from lateral aspect almost twice as long as high, the propodeum not declivous; from dorsal aspect almost twice as long as wide; pronotum coarsely rugose-punctate and with scattered long setae; scutum with moderately large subconfluent punctures with a tendency toward arrangement in longitudinal rows, the punctures not uniform in size; parapsidal furrows obscure, being represented by one of the rows of punctures; scutellum with large dense punctures; scutum and scutellum with scattered pubescence; postscutellum not prominent, as a very transverse plate; propodeum long, laterally finely densely punctate and with white pubescence, at meson with several more or less obscure longitudinal carinae, between which the surface is coarsely rugose-punctate; pleurae densely punctate, the punctures moderately small. Forewings normal; when closed failing by a little to reach apex of abdomen; smoky, the basal third pale; venation pale yellow and indistinct; a small distinct stigmal spot is present. Abdomen slender, $2\frac{3}{4}$ times as long as its greatest width, regularly ovate in outline, widest at one-half the length of segment 3 and gradually tapering; segment 1 hardly shorter than the width across its base; 2 one-half longer than 1; 3 scarcely longer than 2, one-half wider than long; 4 hardly shorter than 3, about one-third shorter than the width across its posterior margin; 5 two-thirds as long as 4 and plainly longer than the width across its posterior margin; 6 one-half as long as 5; 1 strongly striate, and rugose between the striae; 2-5 finely densely striate, the striae regular and straight, the surface between finely rugulose or granulate; 6 rugose; segment 4 with a very few scattered fine setae, which are more numerous but still scattered on 5, and moderately dense on 6.

Male.—Agreeing with the female but the coxae are piceous; the punctures on the scutum and scutellum are much larger and confluent; the parapsidal furrows are well marked; the striae fail medially on segment 5 of abdomen, 6 sparsely striate but smooth at meson. Antennae wholly black; scape almost as long as the next four joints combined; pedicel rather small; funicle 1 cupuliform, one-half longer than its greatest width; 2 scarcely longer than its greatest width; 3 a little widened, no longer than 2, a little wider than long, not very much larger than 4; 4-7 wider than long.

Habitat.—North Queensland: Cairns district, throughout the year, two males, a large series of females; Pentland, in September, one female.

Type.—South Australian Museum, I. 11089.

The male was not at first connected with the female, and was described as *S. nigricoxa*.

SCELIO IGNOBILIS new species.

Female.—Length, 3·3-4 mm.

Black; legs, including the coxae, bright reddish-yellow; antennae black, the scape red but dusky apically, the next two joints more or less washed with red.

Head normal; frons and vertex shining; frons with dense punctures of moderate size; punctures on vertex moderately dense, toward occiput confluent and arranged in transverse rugose rows; pubescence of frons and vertex fine, but more pronounced than in *punctaticeps* or *striatifacies:* lower face with striae converging toward the mouth; cheeks densely punctate and with fine silky pubescence. Antennae as in *punctaticeps* and *striatifacies.* Thorax slender; from lateral aspect twice as long as high, the propodeum not declivous; from dorsal aspect almost twice as long as its greatest width; pronotum coarsely rugose-punctate and with fine long pubescence; scutum with rather large punctures of somewhat uneven size, dense but not confluent, with a tendency toward longitudinal arrangement, there being four or five such rows of punctures on the median lobe posteriorly, with a few scattered long setae; parapsidal furrows well marked and complete; scutellum densely punctate; postscutellum visible as a very transverse plate, not prominent; propodeum coarsely rugose-punctate, more finely punctate and pubescent laterally, its posterior angles rounded, at meson with a pair of longitudinal carinae; mesopleurae densely punctate for the most part, the punctures not large. Forewings smoky, the basal portion pale-yellowish; venation pale yellow, indistinct, the stigmal spot small but well marked. Abdomen rather stout, broadly ovate, slightly more than twice as long as its greatest width; segment 1 as long as the width across its base; 2 one-third longer than 1; 3 a little yet distinctly longer than 2, twice as wide as long; 4 distinctly shorter than 3, not more than one-half as long as the width across its posterior margin; 5 plainly shorter than 4, much shorter than the width across its posterior margin; 6 hardly one-half as long as 5; 1 strongly striate and rugose between the striae; 2-5 densely, finely striate, the striae somewhat irregular; striae failing rather broadly at the meson of 4 and 5, the smooth area widening posteriorly; there are more setae and pin-punctures on 4 and 5 than in *punctaticeps* and *striatifacies*.

Male.—Unknown.

Habitat.—North Queensland: Atherton tableland, 2,500 feet, four females in March and April. Central Queensland: Rockhampton, one female in May. South Queensland: Boonah, one female in May.

Type.—South Australian Museum, I. 16078.

Paratypes.—In the author's collection.

Of the three closely-related species, *punctaticeps, striatifacies,* and *ignobilis,* the abdomen is stoutest in the last-named. In *ignobilis,* the smooth median area on segments 4 and 5 of the abdomen is broader than in *striatifacies.* The mesopleurae are densely but not confluently punctate in *punctaticeps* and *ignobilis,* confluently punctate and more or less distinctly striate in *striatifacies.* The parapsidal furrows are not well defined in *punctaticeps,* conspicuous in the two other species. The granulate appearance of the vertex of the head is found in *striatifacies* only.

SCELIO DIEMENENSIS Dodd.

Proc. Royal Soc. of Q'land, Vol. xxvi., 1914, p. 114.

Female.—Length, 3·40 mm.

Black; legs bright reddish-yellow, the coxae fuscous, the femora faintly dusky; antennae wholly black.

Head normal; vertex smooth, with scattered moderately-small punctures; against the occiput confluently punctate and arranged in subtransverse rows; punctures of frons numerous and moderately dense, each bearing a very fine and short seta; antennal impression small and smooth, the lower face with dense striae converging toward the mouth; cheeks rather densely punctate. Antennae normal; pedicel as long as its greatest width; funicle 1 as long and as wide as the pedicel. Thorax slender; from lateral aspect almost twice as long as high, the propodeum not declivous; from dorsal aspect not much less than twice as long as its greatest width; pronotum confluently rugose-punctate and with long fine setae; scutum and scutellum with a very few long pale setae, densely subconfluently punctate, the punctures moderately small and uneven in size; parapsidal furrows subobsolete, indicated by a row of punctures; postscutellum not prominent, as a transverse line; propodeum rather long, its posterior angles obtuse, densely punctate with obscure oblique striae, and at meson with a pair of straight carinae; mesopleural depression finely densely but not confluently punctate; metapleurae confluently punctate with a longitudinal tendency. Forewings normal; lightly smoky, paler at base; venation pale yellow, indistinct, the stigmal spot not well defined. Abdomen $2\frac{1}{2}$ times as long as its greatest width; segment 1 a little shorter than its basal width; 2 two-thirds longer than 1; 3 a little longer than 2, distinctly less than twice as wide as long; 4 as long as 3, a little shorter than the width at its posterior margin; 5 plainly shorter than 4, hardly more than one-half as long as the width at its base, and as long as the width at its posterior margin; 6 short, not as long as its basal width; 1 strongly striate and finely rugose between the striae; 2 densely finely striate; 3-5 densely finely striate, the striae a little wavy and irregular, failing broadly at the meson of 4 and 5 and less so on 3; 6 densely punctate and pubescent.

Male.—Unknown.

Habitat.—Tasmania: Hobart, two females, A. M. Lea.

Type.—In the New South Wales Department of Agriculture, Sydney.

Very near *punctaticeps, striatifacies,* and *ignobilis,* but differing from all three in the more sparsely punctate head. The striation of the abdomen is very similar to that of *ignobilis.*

SCELIO PLANITHORAX new species.

Female.—Length, 3·90 mm.

Black; legs, including the coxae, intense reddish-yellow; antennal scape deep red, dusky at apex, the pedicel dusky-red.

Head normal; upper frons with numerous well-separated small punctures; between the ocelli the punctures are much sparser and very scattered; against the occiput the punctures are dense, subconfluent, and arranged in about two irregular transverse rows; upper cheeks strongly confluently punctate, the lower cheeks smooth except for a few punctures; punctures of frons continued for a short distance on either side of the smooth impression, the lower face with striae converging toward the mouth; pubescence of head consisting of short fine hairs. Antennae normal; scape moderately long and stout; pedicel one-third longer than its greatest width; funicle 1 cupuliform, one-third longer than its greatest width; 2 and the following transverse. Thorax rather flattened; from dorsal aspect almost twice as long as its greatest width; from lateral aspect fully twice as long as high, the propodeum not declivous; pronotum strongly reticulate-punctate; parapsidal furrows very distinct, consisting of a row of confluent punctures; punctures of median lobe of scutum small, dense, but not confluent except against anterior margin; punctures of parapsides less dense; scutellum punctured like the median lobe; postscutellum not prominent, as a transverse line; propodeum long, its posterior angles rounded, with a well-defined pair of median carinae, its surface densely confluently punctate with a suboblique arrangement; mesopleurae with small dense non-confluent punctures. Forewings rather deeply smoky, yellowish at base; venation very pale yellow and indistinct, the stigmal spot small and obscure. Abdomen a little less than three times as long as its greatest width; segment 1 fully as long as its basal width; 2 one-half longer than 1; 3 a little longer than 2, one-half wider than long; 4 slightly shorter than 3, as long as the width at its posterior margin; 5 distinctly shorter than 4, as long as the width at its posterior margin; 6 two-thirds as long as 5, shorter than its basal width; 1 strongly striate, and rugose-punctate between the striae; 2 very densely, rather strongly striate, the surface between the striae shining and feebly sculptured; 3-5 very densely and finely striate, the striae straight and regular, the surface between hardly sculptured, with a median path smooth except for a few fine setigerous punctures, the smooth path narrower on 3; 6 rugose-punctate.

Male.—Unknown.

Habitat.—South Queensland: Mount Tambourine, 2,000 feet, two females in April, A. P. Dodd.

Type.—South Australian Museum.

Paratype.—In the author's collection.

A species of the *punctaticeps-striatifacies* relationship, and most nearly allied to *ignobilis* and *diemenensis.* From *ignobilis* it differs in the sparser punctuation of the head, the more regular, distinctly-separated punctures of the scutum, the more slender abdomen, the presence of the smooth median path on segment 3, and the fact that the median path on 4 and 5 is straight and does not widen posteriorly. From *diemenensis* it differs in the colour of the coxae and antennal scape, the very distinct parapsidal furrows, the more even punctuation of the scutum, and the straight median path on segments 4 and 5 of the abdomen.

Queensland Fruit Flies (*Trypetidae*), Series 1.

By HENRY TRYON, Department of Agriculture, Queensland, late Government Entomologist.

PLATES XX-XXIV.

(*Read before the Royal Society of Queensland, 27th September,* 1926.)

INTRODUCTORY.

AUSTRALIAN AND QUEENSLAND FRUIT FLIES.

The already known Queensland Trypaneidæ (fruit flies) comprise the following species:—

1. *Chæodacus Tryoni,* Froggatt, 1897 (*Tephritis*) = *Tephritis sp.,* Tryon, 1889.
2. *Chætodacus cucumis,* French, 1907 (*C. Tryoni* var. *cucumis,* French).
3. *Ceratitis capitata,* Wiedemann, 1824 (*Halterophora*)*.
4. *Rioxa musæ,* Froggatt, 1899 (*Trypeta*).

In addition, the following fruit flies have been accorded an habitat in Australia, outside the limits of Queensland, by W. W. Froggatt:—

5. *Chætodacus æqualis,* Coquillet, 1908 (*Dacus*).
6. *Chætodacus Froggatti,* Bezzi = *Dacus zonatus,* Frogg, 1910, nec *zonatus,* Saunders, 1841 (*Dasyneura*).
7. *Ceratitis loranthi,* Frogg. 1911.
8. *Lenophila* (*Ceratitis*) *dentipes,* Guérin, 1843 (*Ceratitis*).
9. *Rioxa bicolor,* Macq., 1855 (*Urophora*).

Further there is the Northern Territory fruit fly:—

10. *Rioxa termitoxena,* Bezzi, 1919.

Moreover, M. Bezzi includes in his "Critical Review of the Oriental and Australian Trypaneids (Fruit Flies) hitherto Described" (1913, pp. 65-84), amongst the 334 nominal species from these regions, and taking into consideration the foregoing, a total of 24 different species as credited by their respective authors to Australia, *i.e.,* 14 additional ones.

Of these fourteen fruit fly species, five have definitely been allotted to Sydney (Port Jackson) as the place where originally obtained. These are as follows:—

11. *Bactrocera longicornis,* Guérin, 1832.
12. *Tephritis pelia,* Schiner, 1868.
13. *Tephritis undecemguttata,* Thomson, 1858.
14. *Œdaspis escheri,* Bezzi, 1910.
15. *Rioxa pornia,* Walker, 1849 (*Trypeta*).

* The Queensland occurrence of this fruit fly—commonly found there in imported fruit—is given on the authority of W. W. Froggatt (1909, p. 104).

The further nine distinct Trypetids, that with these five constitute the foregoing number, have merely "New Holland" assigned to them as the place of their occurrence.

As regards the five New South Wales insects above mentioned, we have no evidence of their having been found at Sydney, nor indeed elsewhere in Australia, since the dates when they were described and had this place accorded to them as a type locality. Moreover, apparently no authentically named specimens are discoverable, with one exception only —the *Œdaspis,* whereby they can be recognised.

The published descriptions of these four "New Holland" and "Port Jackson" fruit flies are for the most part of such a nature as not to constitute an adequate account or definition in the case of any one of them, even when the figures illustrating certain of them are taken into consideration. The illustrations, in fact, lack essential details, and the descriptions alluded to are either too brief or do not conform to any recognised system in specifying what may be regarded as characteristics.

There are still other flies of alleged Australian origin, that are enumerated amongst the 334 of Bezzi's "Critical Review" and that, as indicated by him, although placed by the respective authors of the different species in the family Trypaneidæ are now known to be members of species quite distinct from it, a remark that applies to Diptera properly belonging to the Ortalidæ, such as *Dacus æqualis,* Walker, or to other groups. These are, of course, not fruit flies proper: a remark true, too, of the "Black Fruit Fly" (Tryon, 1889, p. 75), one of Queensland's fruit-loving Anthomyidæ.

It will thus serve no useful purpose to treat of them. This remark also applies to the Port Jackson and New Holland fruit flies, seen only in the light of inadequate descriptions as already pointed out.

Fruit Fly Features and Conditions.

In estimating the value to be attached to different features presented by fruit flies occurring in collections, the following facts need be taken into consideration. Insects that have been reared will, unless they have been fed suitably during a period of several days prior to their being killed, have their abdomens collapsed and bent under; or, if not, narrowed and lengthened with segments 1 and 2 unduly extended; and when killed quite early, especially prior to being fed, may have their general colour, including wing-markings, of a lighter hue than is normal. Again, the pale calli spots or bands, that are almost invariably sulphur-yellow in life, will by mere lapse of time be rendered quite inconspicuous.

With regard to structural characters to be relied upon in distinguishing the several species, especially those of *Chætodacus,* the characteristics yielded by the male and female organs, especially those of the forceps in the former sex, have not been here inquired into: notwithstanding the value F. Silvestri has derived from such an investigation (*vide* "Report of an Expedition to Africa in Search of Natural Enemies of Fruit Flies" (Trypaneidæ) (p. 92-95 and Pl. VIII.) would appear to suggest their importance in separating allied species, or species that, on other grounds, may be regarded as varieties of single species.

In the nomenclature relating to the features embodied in the several descriptions, that detailed by M. Bezzi and adopted by him in his "Indian Trypaneids (Fruit Flies) in the collection of the Indian Museum" 1923, and amended and further adopted by this great dipterologist in his "Notes on the Ethiopian Fruit Flies of the Family Trypaneidæ other than *Dacus sen. lat.*" 1918, has been followed, in accordance with this scheme, also illustrated and carried out by Professor Shiraki in his Chinese-Japanese Memoir.—"*Mikau Shogitsugo ni Kwansuru*" (Citrus Fruit Fly Investigation), Formosa, 1921.

The biological features of the several fruit flies treated of, and the nature and extent of the injuries for which they are responsible, as well as all descriptive details regarding their eggs, maggots or pupæ, have been omitted, notwithstanding their importance, since they have not been regarded as coming within the scope of this Memoir, which is technically systematic and intended as an authoritative account of the outward characteristics by which they may be severally distinguished.

Following the course adopted in enumerating the recorded fruit flies of Queensland and of Australia (*vide* p. 176), dipterous flies, whose maggots may occur in the tissues of ripe or even ripening fruit, such as those included in the families Ortalidæ, Anthomyidæ, Lonchæidæ, and Stratiomyidæ, have *not* been subjects of description, since not, perhaps, presenting features in their life economies of any significance.

Where indigenous, plants are named as furnishing fruits wherein the several species of Trypetidæ whilst in the maggot condition dwell, and on whose tissues they subsist, the State Botanist, Mr. C. T. White, F.L.S., has been applied to for their nomenclature, except in cases in which their identification was quite obvious.

Previous Literature.—Up to the present date there has been no systematic account of the species of Queensland fruit flies (Trypetidæ), notwithstanding these are evidently far more numerous than would appear from the present account denominated Series 1. Other Australian entomologists, notably W. W. Froggatt, late Government Entomologist of New South Wales, have, however, incidentally treated of some of our species as denizens of other Australian States. As an exception, however, may be mentioned the fact that Hubert Jarvis, Entomologist, Department of Agriculture, Stanthorpe District, whilst a member of the present writer's staff, wrote a popular descriptive article:—"Fruit Flies of the Granite Belt" (Stanthorpe area), relating to the following local species:—"The Queensland Fruit" (*C. Tryoni,* Frogg.), "The Solanum Fly" (*O. Solani,* Tryon mss. = *C. dorsalis,* Hend.), "The Jarvis Fruit Fly" (*C. Jarvisi,* Tryon mss.), and the "Stanthorpe Spotted Fruit Fly"

(*Rioxa Jarvisi*, Tryon mss.). This was illustrated by coloured drawings. After office revision its text was set up in type about two years since, but, owing to technical difficulties in reproducing the figures in colour, has never yet been printed. In fact, the accompanying plates alluded to are not available at this date (1.7.26), although now complete. This fact constrained the writer to associate H. Jarvis with the latter as joint author of the present memoir. This course, however, our colleague did not favour, but has permitted us to dedicate two of the fruit flies, of which he treated, to him.

Obligations.—The writer, in recognising his obligations, has to refer to Mr. E. Graham, Under Secretary, Department of Agriculture and Stock, for permission to prepare and submit this account of Queensland fruit flies, and for instructing the several field officers on the staff of the Director of Fruit Culture to co-operate by collecting and forwarding fruits of native trees, and to Messrs. S. E. Stephens (Gympie) and A. Wooller (Bowen) for the manner in which they have complied with this order. Similarly, to the Provisional Forestry Board (E. H. F. Swain, Chairman) for so instructing, in like manner, the Deputy Foresters in the several districts of Queensland; and to the very material assistance accordingly rendered by Mr. F. C. Epps, the officer stationed in the Gympie forest district, and to Messrs. E. F. Fitzpatrick, R. W. Sweetenman, and F. Reynolds, members of his staff; also to Mr. J. R. Dawson of the Frazer Island district and his staff; similarly to Mr. T. B. Bourke, Rockhampton forest district, and his coadjutor in the work, Mr. E. J. Richter, Byfield, and again to Mr. J. C. Tardent, Benarkin forest district. The writer further is especially indebted to the following:—Messrs. Heber Longman, F.L.S., Director, Queensland Museum, for loan of literature; H. Jarvis, Entomologist, Stanthorpe, for several fruit flies, including two new species brought to light by his own discoveries; Dr. T. L. Bancroft, Eidsvold, for numerous contributions, including, amongst other distinct species, examples of the northern Banana fruit fly from the native *Musa* (banana), as well as from the cultivated *Musa Cavendishi* (cultivated banana), also for examples of *Chætodacus Tryoni* exhibiting the range in dietary—as a maggot—discovered by this notorious insect; and E. H. Rainford similarly for Bowen species. Further, to J. H. Simmonds and W. A. T. Summerville, both of his staff, the former for contributing fruit-fly-infested native fruits, the latter for bringing to maturity in the insectary the fruit flies yielded by the same as received from different localities. Again, to the State Botanist, C. T. White, and his assistant, W. D. Francis, thanks are due for plant identifications, and gratefulness is especially entertained towards the artist, I. W. Helmsing, for the skilful delineation of the several fruit fly species shown in the plates with which this memoir is illustrated.

Types.

The types of all species of Trypetidæ herein regarded as new are being deposited in the Queensland Museum, and are now registered under the accession numbers assigned by that institution.

QUEENSLAND FRUIT FLIES.

Tabulated Arrangement.

CHÆTODACUS SENS. LAT.

1. General colour yellow, yellow-brown, or red-brown, length exceeding 4 mm. .. 2.
General colour black, length not exceeding 4 mm. .. *C. niger* sp. nov.

2. Wing with a single dark band involving hind cross vein widely, and attaining costal band or not .. .. 13.
Without cross band .. .. 3.

3. Markings of mesonotum (if any) brown .. .. 4.
Markings of mesonotum black and conspicuous .. .. 9.

4. Scutellum with apical pair of bristles only .. .. 5.
Scutellum with basal and apical pairs .. .. 12.

5. Costal cells of wings coloured .. .. 6.
Costal cells of wings uncoloured (*vid.* also 9.) .. .. 8.

6. Costal cells of wings pale horn-yellow .. *C. tryoni* Frogg. and its varieties.
Costal cells of wings fuscous .. .. 7.

7. Costal marginal band filling marginal and sub-marginal cells *C. bryoniæ* sp. nov.
Costal marginal band filling marginal, submarginal and 1st posterior cells *C. æqualis*, Coquillet.

8. (*a*) A noto-pleural pale yellow stripe (uniting humeral and noto-pleural calli) and (*b*) anterior supra-alar bristle absent .. *C. Jarvisi* sp. nov.
(*a*) . . . . absent. (*b*) . . . . present .. .. .. *C. Fagræa*, sp. nov.

9. Black area of mesonotum confined to lateral (dorso-lateral) blotches (3); facial spots pointed anteriorly .. .. .. *C. Halfordiæ*, sp. nov.
Both otherwise .. .. 10.

10. Black area of mesonotum, a mesial narrow lanceolate stripe, with apex at fore and base at hind border .. *C. dorsalis*, Hendel (and varieties).
Black area of mesonotum, not lanceolate, and occupying almost entire surface of notum, with lateral præsutural extensions (*vid. C. Bryoniæ* sp. nov. .. .. 11.

11. Abdomen entirely reddish-yellow, scutellum with broad fuscous band between origins of apical bristles .. .. .. *C. Bancrofti* sp. nov.
Abdomen the same, scutellum wanting tranverse band *C. Musæ*, sp. nov.

12. Meso-notal pale yellow stripe from suture to 2/3 ns. towards scutellum; infero-orbital bristles 3. 5th longitudinal distinctly fuscous at end. No spot on 5th abdominal segment .. .. *Dacus cucumis* Fr.
Meso-notal pale yellow stripe from level of humeral calli almost to scutellum; infero-orbitals 2; 5th longitudinal vein not infuscated at end; spot on 5th abdominal segment above distinct .. .. *Dacus signatifer*, sp. nov.

13. Dark band very conspicuous narrowing from a wide base to costal border. No oval fuscous spot at apex of wing .. *Bactrocera pulcher* sp. nov.
Dark band less conspicuous, not attaining costal band, and this ending in a large oval spot at end of 3rd longitudinal vein *Bactrocera caudatus*, Fabr.

RIOXA.

1. Mesonotum white with longitudinal black stripes, abdomen upper surface with segments 1-4 white-banded transversely: pale or brownish yellow .. .. *R. araucariæ* sp. nov.
Mesonotum and abdomen otherwise marked .. .. 2.

2. Abdomen above parti-coloured,black with segments 1, 2, and middle of 3 and venter white; wings* with 2 discoidal spots .. *R. Musæ* (Frogg.) Bezzi.
Abdomen above black, 3-white banded with segments 1-3 only whitish beneath; wings with 3 discoidal spots .. .. *R. jarvisi*, sp. nov.

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* The pattern of wings in other respects widely different in these two species, and that of neither manifests any correspondence with the wing pattern of *R.araucariæ* sp. nov.

Gen. CHÆTODACUS Bezzi.

CHÆTODACUS* TRYONI (Froggatt). (Pl. xx., Fig. 1 male, Fig. 2 female.)

THE QUEENSLAND FRUIT FLY.

Tephritis sp.—Tryon, H., "Report on Insect and Fungus Pests" (1) p. 54-60, Brisbane, 1889.

Tephritis Tryoni.—Froggatt, W. W., "Agricultural Gazette of New South Wales," viii., 1897, p. 410, pl. figs. 1-8.

Tephritis Tryoni.—Froggatt, W. W., *op. cit.* x. (1899), p. 498 (without description).

Dacus Tryoni.—Froggatt, W. W., "A General Account of the Flies belonging to the Family Trypetidæ," Sydney, 1909, p. 11-23, pl. 1, and pl. iv. 1 (wing), *s.v.* "The Queensland Fruit Fly." [Also in several reprints of this.]

Male and Female. Measurements—

Male.—Length of body 7 mm., of wings 5·6 mm.; *female.*—Length of body 7 mm., of ovipositor ·75 mm., of wing 6 mm.

Head.—Pale brownish-horn colour, occiput pale yellowish-brown, post orbital portion of paler hue; vertex-ocellar spot black with a small brown blotch on each side (this often absent in the species); frontal spots more or less distinct especially superior one: face pale yellow, lighter anteriorly its fore-border little raised—almost level in front of depression, spots circular distinct remote from fore-border, cheeks greyish-white; antennæ-joints 1 and 2 subequal, orange, joint 3 with fuscous upper outer surface tip darker; palps orange, proboscis and tongue lighter yellow; cephalic bristles as follows:—vt. outer brown, inner dark-piceous; s.or. 1, i.or. 2, all black; gular dark; ocp. black—usually 7.

Mesonotum.—Yellowish-red with paler yellow appressed pubescence, white erect pubescence on border in front of humeral calli and mesonatal stripe, central-dorsum occupied with a broad greyish fascia, lateral dorsal area reddish-brown and within this on each side a lateral dark-brown longitudinal band arched from inner side of humeral callus nearly to hind border following the curved upper margin of supra-alar stripe along its full extent, below it the lower side also red: scutellum yellow with apical pair alone of dark long bristles; meso-phragma broadly piceous at sides, this piceous colour extending downwards behind the hypo-pleural calli, central area pale brown anteriorly, then suddenly narrowing posteriorly to a slender mesial band: anterior half of meso

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* The definitions of *Dacus sens. lat.*, *Dacus sens. strict.*, *Chætodacus* and *Bactrocera* that are detailed by M. Bezzi ("On the Fruit Flies of the genus *Dacus* (*s. l.*) occurring in India, Burma, and Ceylon," 1914, and accepted by Hendel in his "Die Gattungen der Bohr Fleigen: analytischen übersicht aller bisher bekannten gattungen der Tephritinæ) (Wien entom. Zeitung, XXXIII., ap. 1914, pp. 73-98) have been followed throughout this paper.

pleuron, anterior sterno-pleuron and pectus piceous: calli and bands and spots bright lemon yellow as follows:—humeral callus, noto-pleural, meso-pleural, sterno-pleural, hypo-pleural (2) and supra-alar stripe: thoracic bristles (Chætotaxy) as follows:—sa. subequal, n.pl. 2, pr. sc. 2, a.sa. 1, and p.sa. 2 alike brown, a.sa. decumbent, m.pl. and pt.pl. both black.

Abdomen.—Of a general brown colour clothed above with hoary adpressed pubescence, segment 1 (basal segment) brown and occupied with little low excrescences, segment 2—anterior part whitish posterior flavous or pale-yellow without definite intervening line—the boundary being sigmoid so that in the middle the whitish area of the segment occupies nearly half the length of this segment whilst it narrows and vanishes on each side. Segments 3 to 5 brown, deeper tinted at the sides and suffused with yellow in centre, a dark grey mesial longitudinal score —seen by oblique light especially—traversing them, oval area on each side of fifth large—involving nearly entire length and width of segment, its surface occupied sparsely by a few small granules: Ovipositor in female, basal portion (segment 7) elongate triangular lowly conex both above and below. Male with pecten of black bristles on the hind border of 3rd segment on each side above.

Wings.—The veins dull yellow except when traversing or bounding coloured areas when they are fuscous: marginal cell very narrow the 1st and 2nd longitudinal bounding it coalescing just at small cross vein, the second basal cell somewhat wider beyond 2/3 length: the costal-band—commencing at wing base—is dull pale yellow where it involves the costal cells, pale fuliginous where the stigma, and darker fuliginous beyond being narrowest where it occupies the marginal cell, the wider portion following the wing margin to nearly half way between 3rd and 4th longitudinal veins, ending abruptly, *i.e.*, without either enlarging or becoming attenuated, the narrow portion of the first basal in front of the 2nd basal cell is also fuscous, the anal stripe comprises a band through the anal cell continued in its extension, and a broader one along the inner side of the 3rd posterior cell contiguous to the anal cross vein and the extension of the cell that it bounds. This, in the male, is continued in an indefinite dark patch in the outer angle of the axillary cell. In this sex, moreover, the supernumerary cell has only a small development.

Legs.—Yellow with the tibiæ and tarsi suffused with brown, the hindmost ones being fuscous except on their inner surfaces, the ungues and spinelets at end of tarsal joints black: two longitudinal parallel rows of thin black spines occur on the outer surfaces of the front femora, one extending along its length, the other shorter; spine at end of intermediate tarsi black.

Types.—Reg. No. Q.M.D. 3119, Plesiotypes—male and female.

Note 1.—The colouration of the costal cells of the wings—translucent but yellow, and the constant absence of any trace of black on the mesonotum ("thorax") slight traces only being found in varietal forms, and the absence of a mesial longitudinal noto-pleural stripe are characteristic.

Note 2.—The original description of this fruit fly was published by the writer in 1889. (1) "Inquiry into Diseases affecting the Fruit Trees and other Economic Plants in the Toowoomba District," Brisbane, by authority, 1889 (Parl. Paper); *s.v.* "The Fruit Maggot, Fruit Fly—*Diptera* Gen. Tephritis," *op. cit.* 26-35, *cf.* pp. 27-28; and (2) "*Insect* and Fungus Pests," Brisbane, 1889, pp. 57-59 (Reprint of (1)). This was fully comprehensive, and, although couched in technical terms other than those now used, adequately characterises the species.

Eight years subsequent to this, the insect having then (fruit season 1896-7) shown unusual prevalence in New South Wales, W. W. Froggatt, whilst referring to the foregoing, gave a general account of the insect ("The Fruit Maggot Fly *Tephritis tryoni,* n.sp." "Agricultural Gazette N.S. Wales," viii., p. 410-12, Pl. fig. 18). This is evidently based on examples of a fruit fly bred in his office from fruit (? apples—H.T.) received from Tenterfield, N.S.W., in February, 1897 (cf. *op. cit.*, p. 410), and notwithstanding the meagreness of his description, the excellent plate wherewith he illustrates his account of it renders it evident that he is dealing with the one now under consideration. The plate, moreover, bears the legend—"Queensland Fruit Fly"—*Tephritis Tryoni,* n.sp., and in a footnote its author informs us that he has so named it "as Mr. Tryon informs him it is an undetermined species," &c. Later, W. W. Froggatt, in his "Notes on Fruit-Maggot Flies, with Descriptions of New Species" ("Agr. Gaz. N.S.W.," x. (1899), pp. 497-504) and under "Queensland Fruit-Maggot Fly—*Tephritis Tryoni,* Frogg." (*op. cit.*, p. 494) again deals with this trypetid, remarking:—"This species has been well described by Tryon" (referring to our 1889 account of it). However, he informs us:—"The only specimens of this species that have been bred in our office are those (from maggots in) overripe or decaying bananas and other Northern fruits that have been condemned at our wharves" (*op. cit.*, p. 498), and although this statement might be regarded as throwing doubt on the identity of the insect, with which he is dealing, with his *T. Tryoni,* the plate accompanying this paper is conclusive to the contrary on this point.

Froggatt, after an interval of ten years, again treats of the "Tryon Fruit Fly" in his valuable "Report on Parasitic and Injurious Insects," 1907-8, Pt. III., "Fruit Flies," "The Queensland Fruit Fly—*Dacus Tryoni,* Froggatt. This embodies a further short description, but whilst this does not allude to the wing-features, the figure that he gives of a wing (Pl. 1, fig. 1) renders it additionally evident that the species that he is dealing with is the one concerning which our remarks are being made. These accounts, by the former New South Wales Government Entomologist, have in each case been subject of reprints, the original plate published by him in 1897 accompanying them. This historical note need not be burdened with H. Tryon's published accounts, subsequent to 1889, of this fruit fly, since they principally dealt with it from an economic standpoint.

Plant Hosts.—The following is a list of the plant-species whose fruits have served as hosts for this notorious Australian fruit fly:—

Indigenous Flora.—

Anonaceæ.—(1) *Melodorum Leichhardtii*, Benth.

Capparideæ.—(2) *Capparis nobilis*, F. v. M.; (3) *Capparis*, sp. indeter.

Rutaceæ.—(4) *Acronychia lævis*, Forst. ("Cheese Wood," &c.); (5) *Atalantia glauca*, Hook f.

Meliaceæ.—(6) *Owenia venosa*, F. v. M.

Celastrineæ.—(7) *Elæodendron australe*, Vent.

Rhamneæ.—(8) *Siphnodon australe*, Benth.; (9) *Ziziphinus jujube*, L.

Sapindaceæ.—(10) *Atalaya hemiglauca*, F v. M.

Anacardiaceæ.—(11) *Spondias pleiogyna*, F. v. M. ("Burdekin Plum").

Saxifrageæ.—(12) *Schizomeria ovata*, D. Don.

Saxifrageæ.—(13) *Davidsonia pruriens*, F. v. M., Davidsonian Plum.

Combretaceæ.—(14) *Terminalia* sp.

Myrtaceæ.—(15) *Psidium guayava*, Linn ("Guava") naturalised.

Myrtaceæ.—(16) *Eugenia Smithii*, Poir.

Passifloreæ.—(17) (*Passiflora aurantia*, Forst.)*

Cactaceæ.—(18) *Opuntia ficus-indica*, L.

Rubiaceæ.—(19) *Sarcocephalus cordatus*, Mig. ("Leichhardt Tree").

Sapotaceæ.—(20) *Sideroxylon pohlmanianum*, F. v. M.; (21) *Sideroxylon australe*, R.Br. ("Black Apples").

Ebenaceæ.—(22) *Diospyros australis*, R. Br.

Oleaceæ.—(23) *Notelæa longifolia*, Vent.

Apocynaceæ.—(24) *Carissa ovata*, R. Br.; (25) *Ochrosia elliptica*, Labill.

Cucurbitaceæ.—(26) *Bryonia laciniosa*, Linn. (T.L.B.).

Solanaceæ.—(27) *Solanum aviculare*, Forst.

Laurineæ.—(28) *Endiandra compressa*, C. T. White.

Urticaceæ.—(29) *Ficus Watkinsoniana*, F.M.B., (*Ficus stephanocarpa* ?); (30) *Ficus glomerata*, Wild.

Cultivated Flora.—

Anonaceæ.—(1) *Anona cherimolia*, Mill., Custard Apple.

Bixineæ.—(2) *Flacourtia cataphracta*, Ross, "Flacourtia"; (3) *Aberia caffra*, Harv. & Sond., "Kei Apple."

Rutaceæ.—(4) *Citrus aurantium*, L. orange; (5) *C. decumana*, Lour., Pomelo; (6) *C. nobilis*, Lour.; (7) *C. japonica*, Mandarin; (8) Kumquat; (9) *C. limonum*, Risso, Lemon; (10) *Ægle marmelos*, Cort., Bengal Quince.

Rhamnaceæ.—(11) *Zizyphus jujuba,* L. Jujube.

Ampelidæ.—(12) *Vitis vinifera,* L. Grape; (13) *V. labrusca,* L., Isabella Grape.

Anacardiaceæ.—(14) *Anacardium occidentale,* Tar Wood Tree or Cashew; (15) *Mangifera indica,* L. Mango.

Rosaceæ.—(16) *Cydonia oblonga* Quince; (17) *Eryobotrya japonica* Lindl., Loquat; (18) *Prunus persicus,* Stokes, Peach; (19) *P. domestica,* L., Plum; (20) *P. armeniaca,* L., Apricot; (21) *P. levis,* D.C., Nectarine; (22) *P. cerasus,* L., Cherry; (23) *Pyrus malus,* L. Apple; (24) *P. communis,* L. Pear; (25) *Rubus fruticosus,* L. Blackberry.

Lythraceæ.—(26) *Punica granatum,* L. Pomegranate.

Myrtaceæ.—(27) *Eugenia braziliensis,* L. Brazilian Cherry; (28) *Psidium guyava,* Guava; (29) *P. cattleianum,* Sabin, Cherry Guava; (30) *P. littorale,* Radd., Small Yellow Guava.

Passifloraceæ.—(31) *Carica papaya,* L. Papaya or Paw Paw; (32) *Passiflora edulis* Sims., Passion Fruit; (33) *P. quadrangularis,* L. Grenadilla.

Cactaceæ.—(34) *Opuntia ficus indica,* L. Edible Prickly-pear.

Ebenaceæ.—(35) *Diospyros kaki,* L. Persimmon.

Oleaceæ.—(36) *Olea sativa,* L. Olive.

Solanaceæ.—(37) *Lycopersicum esculentum,* Mill. Tomato; (38) *Capsicum annuum,* L. var. *grossum,* W. Giant Chili or Pepper.

Urticaceæ.—(39) *Ficus carica,* Lin. Fig.

Moraceæ.—(40) *Morus alba,* L. Mulberry.

Jugulandaceæ.—(41) *Jugulans regia,* L. Walnut.

Musaceæ.—(42) *Musa cavendishi,* L. Cavendish Banana.

Palmaceæ.—(43) *Phœnix dactylifera,* Date.

Habitat.—This fruit fly, although designated by W. W. Froggatt the "Queensland Fruit Fly," is a native of coastal New South Wales as well as of this State. In fact, he has stated that "it ranges as far as Gosford, 50 miles north of Sydney." H. Tryon, writing in 1889, adduced evidence also that it was met with, damaging fruit, at Port Macquarie as early as 1865. In Queensland it not only occurs throughout the coastal district, but passes far beyond the Dividing Range, even so in the North.

The Queensland Fruit Fly, a Native Species.

Chætodacus Tryoni, Frogg., was regarded some years since as identical with a fruit fly occurring in India, *C. ferrugineus,* Fabricius (Musca).

This identification was made by Bezzi in his memoir, "Indian Trypaneids (Fruit Flies)," &c., 1913. But it does not appear that he had typical examples of *C. tryoni* before him when it was published, much less H. Tryon's description cited by its author, W. W. Froggatt. Thus he writes under *Dacus tryoni*:—"To judge from a specimen from

Peradniya, Ceylon, labelled by Mr. Froggatt himself, *Dacus Tryoni* is synonymous with the present species (*Bactrocera ferruginea* (Fabr.) Bezzi); the specimens bred from fruits which I have received from Gospad (Gosford) district, New South Wales, through the kindness of Mr. Froggatt, approaching the following variety:—var. *mangifera* Cotes''; regarding which he writes, however:—''It is very probable that this variety is based on bred specimens (*i.e.*, of *B. ferruginea*), its colouring and the peculiar shape of the abdomen depending only on immaturity.'' (*Op. cit.*, p. 95.)

Elsewhere in the same Memoir, Bezzi again states:—''267—*tryoni* (*Tephritis, Dacus*), Froggatt, 1897 (Agric. Gazette, New South Wales, 410, pl. 8, fig. 1, and Report 1909, 79, pl. 4, fig. 1 and pl. VI.) from Australia, a true *Bactrocera*, with two scutellar bristles, the same as *ferruginea*. ''Type in Sydney.'' *Op. cit.*, p. 80.

It would appear thus that Bezzi has pronounced this conclusion on comparing two insects both labelled by W. W. Froggatt, the one from Ceylon—''*D. ferrugineus*, Fabr.''—the other from Gosford, New South Wales—''*D. tryoni.*''

Now there is before the writer a specimen of a fruit fly male, also labelled by W. W. Froggatt:—''*Dacus ferrugineus*, Fab. Ceylon,'' and ''Ceylon Froggatt 1908.'' This insect is certainly not the same as *Dacus tryoni*, Frog., the so-called Queensland fruit fly—the black mesonatum, the black band along the margin of the 3rd abdominal segment, the black line proceeding backwards from the centre of the latter, and the hyaline costal cells being features that it exhibits that are not met with in Froggatt's species—*D. Tryoni*. Indeed, the Ceylon fruit fly more nearly approaches a form of the *C. ferrugineus* series that is described in this brochure as having been taken at Buderim Mountain, South Queensland:—*C. dorsalis*, Hendel var.

With reference to the Gosford fruit fly assigned to *Dacus Tryoni* Frogg. by W. B. Gurney, in his valuable ''Fruit Flies and other Insects attacking Cultivated and Wild Fruits in New South Wales'' (Agr. Gaz. New South Wales, Parts 1, 2, and 3, Vols. XXI., 1910, XXII., 1911, and XXIII., 1912), written under the direction of Mr. Froggatt, and an example of which fly was evidently communicated to M. Bezzi, Gurney writes as follows:—''It is noted here that the Queensland fruit fly bred in the Gosford-Narara district and other coastal districts appear to be a distinct var. of the Queensland species—*D. Tryoni*, Frogg. We have developed some 18,000 specimens, and they are decidedly smaller and darker than the Queensland specimens.'' Part 2, *op. cit.*, p. 722. He further states:—''Within the district we have found actually thousands of these flies as maggots in the wild fruits from January to March, and numbers have been developed from them in our breeding cages, whilst scarcely any infection of cultivated fruit has occurred throughout the district during our investigations,'' and yet, as he informs us, ''ripe oranges, cumquats, peaches, &c., remained untouched in adjacent orchards,'' *i.e.*, adjacent to these native-fruit-bearing trees, that yielded freely the flies that he regarded as *D. tryoni*, Frogg.; but with the aforementioned qualification. This circumstance Gurney dwelt upon as indicative of the preference of a native fruit fly for a native Australian fruit.

Again, it may be added that Froggatt, writing on "*Dacus Tryoni*, Frogg., the Queensland fruit fly," summarising W. B. Gurney's observations and alluding to the preference that the fly they dealt with manifested for native fruits, states:—"This tends to show that this fruit fly is a *native* of the coastal districts of New South Wales as well as of Queensland" (Notes on Fruit Flies, Pr. Lin. Soc. N.S.W. 1910, xxxv., and Nov., 1911, p. 865); thus regarding the Gosford and certain Queensland fruit flies as one.

There are, again, before the writer two specimens of the Gosford fruit fly communicated by W. B. Gurney himself, labelled:—"Cheesewood berries. Narara, N.S.W., 1910." Unfortunately, they are much bleached and shrunken, having been long in alcohol, and only in one is a trace of black persisting on the mesonotum. However, the abbreviation of the supra-alar band ending well in front of the upper posterior supra-alar bristle suggests distinctness from *C. Tryoni*, Frogg.

Hitherto the New South Wales fruit flies included in *Chætodacus* have been regarded as belonging to a single species, *Chætodacus Tryoni*, Frogg., and possibly, therefore, exponents of more than one kind have been issued by entomologists there under that name, and hence the ascription by Bezzi of a Gosford (New South Wales) yielded fruit fly to *Bactrocera ferrugineus* (Fabr.) now *Chætodacus ferrugineus* (Fabr.).

This great authority informs us that only species or forms of the "ferrugineus group" (i.*e.*, those conforming to the typical Fabricius species, and several fruit flies that are regarded by him as sub-species of it—*e.g.*, *indicus*, Walker, *dorsalis*, Hendel, *pedestris*, Bezzi, *varsicolor*, Bezzi, &c.) are attracted by oil of citronella, and the figures of all of them that have been issued under his direction exhibit *colourless costal cells*. Now the Queensland fruit fly, that we are considering, is noteworthy in not manifesting either of these distinguishing features of *C. ferrugineus*, Fabr., *sen. lat.* (*Note.*—The latter—the wing-feature alluded to—was originally mentioned by H. Tryon, in his description of the insect, as a *Tephritis*—in 1889, and is illustrated by Froggatt, who named it *Tephritis Tryoni*, in the several figures of *C. Tryoni* that grace his publications—notably in Plate (1), fig. 1. (Report for 1907-8), and is, therefore, a type character.

The purpose of this discussion is to maintain for this insect its distinctness from a previously described species, and its claims to be regarded as a native fruit fly, a matter of more than scientific import.

VARIETIES OF CHÆTODACUS, FROGGATT.

Several varieties of the typical species may be characterised. These have special host-relationship. Thus we have:—

A. *Chætodacus Tryoni*, Frogg., *var. Musa, var. nov.*—Specimens of fruit flies conforming generally to the typical *C. Tryoni* yielded by the insects from Geraldton, Gympie, Buderim Mountain and Stanthorpe Districts (imported) all reared from maggots infesting banana fruits, have been examined, after being first isolated as distinct, without any constant characters being revealed whereby they can be distinguished from it in matters of detail. Their general facies, difficult to define in words, perhaps separating them from typical *C. Tryoni,* Frogg.

B., *Chætodacus Tryoni,* Frogg., *var. Juglandis, var. nov.*—As in typical C. Tryoni, but the mesonotum having the area immediately above supra-alar stripe narrowly fuscous posteriorly, a fuscous spot also internal to humeral callus at base of outer scapular bristle and a dark impunctuate narrow fuscous stripe at scutellar border. Moreover, the anterior supra-alar bristle is not decumbent and is therefore conspicuous. In the wing the portion of the costal stripe bordering the sub-marginal cell at its end is waved on inner side, the anal stripe moreover appears unusually broad—the portion within the third posterior cell paler than that in the anal cell and nearly attaining the basal cross vein. The chætæ of head and thorax are dark fuscous.

Type.—Reg. No. D. 3120, Q.M., female.

Host.—Walnut (H. Jarvis) ; *Locality,* Stanthorpe.

C. *Chætodacus Tryoni,* Frogg., var. *Sarcocephali, var. nov.*—In this the mesonotum is marked with black as follows:—On each side of the mesial grey fascia a spot or narrow band contiguous with the fore border, this may be sub-circular, or directed towards the suture—be drawn-out and then become obsolete—or again passing by it attain nearly the hind border; isolated or merged with it a spot may occur above the interval between the noto-pleural calli; again a line sometimes absent may define above the supra-alar yellow vitta; the abdomen also dark fuscous, a *white narrow line defining segments* 1 *and* 2, in addition to pale line along hind border of segment 2.

Type.—Reg. No. D. 3121, Q.M., 2 females and male.

Host.—Specimens of the fly were reared from Leichhardt Tree, *Sarcocephalus cordatus* Mig. Rubiaceæ, fruit that had fallen and become almost dry. Also a single example occurred amongst twenty or more specimens of typical *C. Tryoni* reared from Psidium fruit, the tree growing close to former. *Locality,* Brisbane (H.T.).

(A distinct species—probably; but the bred examples before us being ill-nurtured this question must be now held in abeyance.)

CHÆTODACUS FAGRÆA, sp. nov.

The Fagræa Fruit Fly, Tryon.

Male and Female. Measurements—

Male.—Length of body 6·5 mm., of wing 6 mm. *Female.*—Do. body with ovipositor extended 7 mm.; ovipositor 1 mm.; wing 6·5 mm.

Head.—Pale, reddish-brown (in dry example whitish); occiput, basal two-thirds brown, post-orbital band whitish; vertex—ocellar spot in acute angled triangle its apex anterior, the bristle spots pale brown conspicuous, s.or. ones subquadrate approximate, i.or. ones merged with mid-frontal spot, and then attaining lunule; lunule with a central black spot; frons rather narrow; face in central line convex behind, almost level anteriorly—the concavity very shallow; facial spots broad narrowed to a point that falls short of mouth border, gular spot transverse narrow indistinct; antennæ—joints 1, 2 subequal, latter hairy with a short dorsal bristle, joints 3 infuscated on outer surface, bristle long blackish pale at base; palpi, yellowish apparently unusually long—exceeding oral border; cephalic bristles—v. 4 subequal, s.or 1, i.or 2, latter paler, oc.p. about 6 dark, gular present, all dark-brown.

Mesonotum.—Pale reddish-brown, and with appressed very short pale pilosity, a centro-dorsal greyish hoary band without longitudinal dark stripe; pleura and pectus not infuscated; yellow calli spots and bands as in C. Tryoni; the supra-alar stripe slightly narrowed posteriorly attaining upper p.sa. bristle; scutellum yellow with two apical bristles only; mesophragma brown with central $\frac{1}{3}$ yellowish; thoracic chætotaxy, sa. 4 the 2 central longer, pr. sc. 2, n.pl. 2, m.pl. 1, ia, 1, a.sa. 1, p.sa. 2, all bristles dark-brown except m.pl. lighter.

Abdomen.—Yellowish-brown, with tawny appressed pilosity, segments 2, 3, 4, and 5 each with dark-brown patch at sides, segment 2 with posterior half whitish transverse continuous band contiguous with hind borer, segment 3 with the lateral bristles black continued to under surface where longer, oval glabrous patch on segment 5 finely punctured (that of female almost occupying entire side), ovipositor—sheath with segments (abdominals 6 and 7) indistinguishable very long-plus 1 mm., widened in the middle by a membranous low expansion on each side, without longitudinal groove above, but tristriated laterally.

Legs.—Yellow horn coloured, tibiæ of hind-pair with hind face fuscous.

Wings.—Costal cell hyaline uncoloured; costal stripe not exceeding 2nd longitudinal but—as usual—passing along sub-marginal cell at apical border and ending abruptly half-way between 3rd and 4th longitudinal veins, 1st basal cell before 2nd cell fuscous as also stigma, anal stripe formed by anal cell and inner part—widely—of 3rd posterior cell, passing—in male—across 6th longitudinal at wing margin, supernumerary axillary lobe in male scarcely evident.

Types.—Reg. No. D. 3122, male and female.

Host.—Fruit of *Fagræa Mülleri,* Benth. (Loganaceæ)—crimson-lake-coloured (E. Jarvis). *Hab.*—Babinda, N.E. Queensland; bred at Entomological Station (Bur. Sug. Exp. Stn.), 2nd June, 1925. (R. W Mungomery.)

Note.—This fly is possibly identical with *C. Tryoni* Frogg., but its general light colour, the colourless costal cells, the length and form of the ovipositor, and its size, seem to separate it from that species. The colour and general facies of this fruit fly recalls that of *D. cucumis* (Fr.) that also extends northwards to the Cairns district; but the latter is at once distinguished by the greatly reduced chætotaxy that characterises it—even generically.

CHÆTODACUS HALFORDIÆ, sp. nov.

THE HALFORDIA FRUIT FLY.

Male and Female. Measurements—

Male.—Length of body 5 mm.; of wing 6 mm. *Female.*—Length of body 6·5 mm.; of wing 6 mm. (*vide* Note, p. 191).

Head.—Pale brownish horn-coloured; occiput without markings; frons-ocellar spot small within a brown triangular mark acutely angled anteriorly, the orbital spots and middle spot also yellowish-brown and distinct; face gradually sloping upwards in front of depression towards mouth-border, facial spots distinct pointed anteriorly, gular spot indistinct; lunule narrow arcuate with central black spots; antennæ extending beyond face, joints 1 and 2 subequal, joint 1 with short yellowish cilia at end above, and joint 2 with a patch, and 1 with a longer hair of this colour on upper face, joint 3 fuscous outwardly and above, bristle with basal portion yellowish; palps oblong compressed yellowish; cephalic bristles as follows:—vt. 4 equal, ocp. 8 short black, s.or. 1, i.or. 2, genal slender, all except ocp. dark piceous.

Mesonotum.—Yellowish-brown, a central broad dorsal vitta slightly narrowed anteriorly to thoracic border grey with pale appressed pubescence, a broad prescutellar transverse band between it and posterior border, dorso-lateral region with three distinct but ill-defined fuscous blotches, one touching fore-border above humeral callus, one in front of suture, and one above supra-alar yellow band, meso-pleural region distinctly black both in front and behind callus, pectus or meso-thoracic pleura also occupied with a black mesially broken blotch; scutellum broad yellow; meso-phragma central $\frac{1}{3}$ yellowish-brown broadly fuscous laterally; calli and stripes yellow as follows:—humeral, noto-pleural, meso-pleural, a relatively narrow parallel-sided band continuous with last above—and with small sterno-pleural below, supra-alar stripe rather narrow of even breadth reaching p.sa. bristle behind, hypo-pleurals 2 distinct—in each the hind border broadly black, no meso-dorsal or præ-sutural lateral stripe. Thoracic bristles—scutellar 1 pair apical piceous, scp. 4, pr. sc. 2, n.pl. 2, m.pl. 1, inf. al. 1, p.sa. 2, a.sa. 1, all piceous—the scapulars a little lighter; halteres white.

Legs.—Yellowish and with very short pale yellow appressed pubescence, the tarsi fuscous above, spur at end of middle tibia black, fore-femora with a few black bristles on upper surface.

Wings.—Veins—the 1st longitudinal closely adjacent to 2nd, towards its base making marginal cell very narrow here, anal cross vein running straight, not bent inwards at its base (as in *C. Tryoni*, &c.), causing anal cell extension to be parallel-sided. Costal cells hyaline uncoloured, costal band pale-fuscous indistinct except where involving darker-hued stigma, somewhat convexly widening beyond termination of 2nd longitudinal vein and between it and the 3rd, extending to halfway between 3rd and 4th, the usual darkening of 1st basal cell in front of 2nd basal one, anal fuscous stripe occupying anal cell and its extension and—narrowly—3rd posterior cell where bordering it, in the male fly extending across 6th longitudinal vein at its end into axillary cell; and an ill-developed supplemental lobe also present.

Abdomen.—(*Note.*—Individuals under notice ill-fed and thus unduly shrunken and elongated therefore), fuscous above and beneath, segment 1 with its posterior margin and segment 2 almost entirely brownish-yellow above, segment 5 with a darker patch on each side above, segment 6 in female (sheath of ovipositor) rather short and broad also flattened above. (In the male segment 3 and 4 brownish above, segment 3 suffused with piceous at sides).

This fruit fly is related to *C. Tryoni,* but is distinguished from it by its smaller size, a difference in colour and pattern of its mesonotum, the colourless costal cells, the shape of the extension of the posterior expansion of its anal cell, the widening towards the end of the costal stripe, and the shape of the facial spots—one or more of which features also separate it from the other Trypetidæ herein described.

Locality, &c.—Southport, South Queensland. *Host.*—The fruit of *Halfordia drupifera* F. v. M. (Rutaceæ). Three specimens communicated by L. Franzen.

Type.—Regis. No. D. 3123, male and female.

CHÆTODACUS ÆQUALIS Coquillet.

THE LARGE AUSTRALIAN FRUIT FLY, Froggatt.

Dacus æqualis, Coquillet: Report 1907-8, p. 91, Pl. III., 11 (wing), 1909, and Froggatt, W. W., "General Account of Fruit Flies (Trypetidæ)" 1909, p. 26, Pl. VI., fig. 11.

In Coquillet's description, reproduced by Froggatt, of *Dacus æqualis,* the following features may be regarded as sufficiently characterising this species for the present.

Female. Measurements.—

Length, including ovipositor, 8 to 9 mm.

Mesonotum.—Reddish-brown, a streak of pale yellow extending along the meso-thoracic suture each side and crossing the meso-pleura (band uniting the humeral and noto-pleural calli—as in *C. Jarvisi,* sp. nov.).

Abdomen (of female) broadly clavate, slightly longer than the ovipositor of the female. (No reference to the existence of any central abdominal line—if present.)

Wing.—A very broad costal band, including not only the coastal, marginal, and sub-marginal cells and stigma (darker), but also the first basal and first posterior cells ("the front margin from the costa to the fourth vein wholly dark-brown"—Coquillet). Froggatt *loc. cit.,* Pl. III., 1.

"This is one of the largest flies, and is remarkable for the very dark broad ferruginous stripe along the front margin of the wing, the long antennæ and the very wasp-shape body" (? due to fact description deals with bred specimens, H.T.). (Froggatt, W. W., *loc. cit.*)

Host.—Orange. Several specimens were obtained by A. T. Hunter in the maggot state in oranges growing near Gosford, New South Wales. (Froggatt.) The existence of the fruit fly in Queensland, in the Stanthorpe area, has been established by H. Jarvis by his finding it in a "lure" accompanying other fruit flies (H. J. *in. lit.*).

Note.—The chætotaxy of *Dacus æqualis* has not been described, and thus the systematic position of the insect, on which this might be expected to throw light, is uncertain.

CHÆTODACUS BRYONIÆ sp. nov. (Plate XXI., fig. 4.)

The Bryony Fruit Fly.

Male and Female. Measurements—

Male.—Length of body 7·5 mm.; of wing 6 mm. *Female.*—Length of body and ovipositor 8 mm.

Head.—Brownish-yellow, pale beneath; occiput without markings; . . . . ., vertex without transverse bar, a reddish blotch on side of black ocellar spot in some specimens; frons rather broader than half length, not narrowing anteriorly, lateral spots reddish coloured are almost wanting; anterior central spot brown on convexly raised area; face with central part flat, scarcely ascending towards mouth border, lateral spots sub-circular and distinct, gular spot reddish; antenna with 2nd joint longer than 1st; 3rd joint brown terminally darkened, little exceeding twice second, arista piceous with base lighter; cephalic bristles vt. 2 pair, oc.p. about 5 black, s.or. 1, i.or. 2—very indistinct, all dark piceous—almost black.

Mesonotum.—Clothed with short dense appressed yellowish pubescence, almost wholly black showing fundamental reddish-brown colour in places, *e.g.*, spot on upper side of humeral callus, fore-border of transverse suture, pro-pleuron pro-sternum, a line defining meso-pleural callus and above wing insertion; the black dorsal area extending broadly on each side, bounded by the humeral callus, the noto-pleural sulcus, then contracted at the sulcus and passing backwards bounded laterally by supra-alar bands (or it may be described as outwardly convex from hind border to suture following inner side of supra-alar band, bent inwards to exclude a short reddish area embracing both sides of suture, then extending downwards between noto-pleural and humeral callus and directed in a straight line from dorsal side of latter to fore-border) ; scutellum yellow without marking and with two apical bristles; halteres pale yellow; meso-phragma black glossy; calli, spots, and band, light yellow and as follows:—humeral, noto-pleural, meso-pleural band united below with sterno-pleural callus, supra-alar band from suture to hind border scarcely narrowing hindwards, hypo-pleural (of two conjoined forming a band as broad as meso-pleural one; thoracic bristles as follows:—sa. 4 & pr.sc. 2, n.pl. 2, m.pl., a.sa. 1, p.sa. 2, ptero.pl. 1, all dark piceous—almost black.

Abdomen.—Pale red clothed above with dense whitish appressed pubescence; basal 2 segments not closely united, segment 1 black with central red transverse band; segment 2 pale reddish with a central transverse black band narrowing and becoming obsolete towards the sides, segments 3 black except in centre of hind-border; a black mesial longitudinal line extending backwards from latter and gradually disappearing before hind-border of segment 5; ovipositor scarcely flattened unusually short, its first two segments not exceeding 5th abdominal 1st joint (sheath) reddish, 2nd yellowish, 3rd glossy red brown; under surface abdomen pale with the sternal scutes black, successively widening to form a conspicuous black ventral patch on hind-border of 3rd segment above at the sides.

Wings.—Outer section of 4th longitudinal vein arcuate, section between small and hind cross vein equal to latter; costal band dark fuscous, extending beyond wing-apex to 4th longitudinal vein, occupying completely costal cells stigma, and both marginal and sub-marginal cells terminally widening beyond the 3rd longitudinal vein and then abruptly narrowing; of this band the portion occupying the costal cells being yellow by transmitted light, and that embracing the stigma darker than the part beyond; the narrow portion of the 1st basal cell anterior to 2nd basal also fuscous; an anal fuscous stripe also present involving anal cell, and—widely—border of 3rd posterior cell along anal cross vein, the anal cell extension being unusually narrow.

In the male this band appears to be occupied with the narrow dark coloured scales, and is dilated at the end, showing in front to the commencement a bulla such as is described to occur in a Philippine Island Fruit Fly, *C. ablepharus*, Bezzi; the wing-veins included in dark markings blacks, or all of them of this colour.

Legs.—Yellow horn coloured coxæ pale reddish, posterior tibiæ-infuscated.

The black that predominates on mesonotum, and broad costal fascia of wing distinguishes this species from the C. Tryoni Frogg., with which in common it possesses coloured costal cells.

Types.—Reg. No. D. 3124 Q.M. Holo- Allo- and 2 Paratypes.

Hab. and Host Plant.—The fruit fly was reared exclusively from the fruit of *Bryonia lacinosa*, Blackall Range and Brisbane District, and received from Eidsvold, where similarly bred from the same fruit by Dr. T. L. Bancroft.

Note.—Apparently this fruit fly is also similarly associated with the fruit of *Melothria cunninghamii*, F. v. M., an allied cucurbitaceous plant.

CHÆTODACUS DORSALIS, Hendel.

THE SOLANUM FRUIT FLY (Plate XX., Fig. 3—Male).

Syn. Dacus dorsalis, Hendel—"The genus *Dacus* Fabr. 1805 (Diptera), Supplementa Entomologica I, 18, 3, pt., fig. 3, 1912.

Chætodacus ferrugineus dorsalis, Hendel, Bezzi, Philippine Journ. Sc. XV., 5, p. 418, 1919.

**Dacus zonatus,* Howlet—E.M. Bull. Ent. Res. X. Pt. 3, Pl. XIII., figs, 1 and 2 (*non. Dacus zonatus,* Saunders, W.W., 1841).

"The Solanum Fly" H. Tryon *passim* in Reports Entomologist, Department of Agriculture, Queensland.

Male and Female. Measurements—

Male.—Length of body 6 mm., of wing 5 mm. *Female.*—Length of body and ovipositor 7·5 mm., of ovipositor 1·5 mm., of wing 6 mm. (Note exceptionally the male fly may attain a length of 7 mm. with a wing length of 6 mm. In a large series from different sources individual variations below this major limit are very numerous.)

Head.—Occiput broadly brown with the orbital border yellowish and therefore well demarcated; frons of equal breadth and with regular contour brownish yellow. Ocellar spot black continuous on each side with a blackish transverse stripe of same colour, three black spots along each side (fronto-orbital bristles); lunule very short (transversely) black with mesial furrow; face yellow with the usual black spot on each side; antenna, reddish, first and second segments subequal, third joint brown, arista darkening beyond base; cephalic—chætotaxy, v.t. 4—piceous, oc.p.; usually 5 brown, or blackish, s.or 1 i.or 2, gular present, pale-brown.

Mesonotum.—Reddish brown densely finely punctured, clothed with short greyish pubescence; a centro-dorsal narrowly triangular black patch having its base at scutellum and apex at fore border, with a narrow transverse præ-scutellar band of this colour extending laterally from its base, with a smaller black also narrow triangular patch attaining only the suture; the sterno-pleuron, and an oblong patch continuous with it, and ascending broadly along the fore-border of the mesopleuron, also black, mesophragma with downward extension behind post-alar calli, black too. Calli and bands as follows:—humeral, noto-pleural, mesopleural, post-alar (hypopleural), calli, and a post-sutural supra-alar almost parallel sided band, and scutellum light bright yellow. Thoracic bristles as follows:—sa. 4, pr. sc. 2, a.sa. 1, p.sa. 2, n.pl. 2, m.pl. 1. Scutellar 2 terminal, these towards end piceous, paler at base.

* *Note.*—This inclusion of *Dacus zonatus,* Howlet, in the synonomy of the species is based on the figures—cited in the reference—showing the thoracic marking—a black lanceolate longitudinal one. In *Dacus zonatus,* Saunders, as stated by Bigot, as figured by Bezzi (1913, Pl. VIII., fig. 4), and as illustrated in specimens—two specimens from Peach Orchard, Pusa, June, 1905 (W. W. Froggatt), before the writer, "The wing is marked with a small blackish patch, situated at the extremity between the costal nervure and the 3rd longitudinal nervure of Rondani" (Bigot).

Wings.—Costal cell on both sides of cross vein hyaline and entirely non-colourous (not pale flavous as in *D. Tryoni* Frogg.); costal border dark, well defined extending continuously from costal cells to nearly half way between 3rd and 4th longitudinal veins, embracing stigma and marginal cells entirely, and bordering the submarginal one outwardly slightly widening towards its termination, a slight infuscation also in portion of 1st basal anterior to 2nd basal; stigma reddish-brown. Anal stripe distinct, formed by pale yellowish-brown of anal cell and a fuscous band in 3rd posterior cell along anal cross vein and 6th longitudinal. In the male this fuscous band is continued in a patch at the margin of the wing—in the axillary cell. The male fly has also the supernumerary lobe of latter. Costal vein, 1st and 2nd longitudinals axillary and anal cross vein reddish—others yellowish horn-coloured, costal vein, 1st longitudinal, and 3rd towards its base spiny.

Legs.—Yellow, the tibiæ of 3rd pair brown; spine at end of tibiæ of 2nd pair, and tarsal spinelets black.

Abdomen.—Reddish with appressed greyish white pubescence above with 1st segment infuscated, 3rd segment with a black patch occupying broadly each side, these united with a band of the same colour along the fore-border, the lateral black colouration involving 4th segment and base of 5th, and continued beyond in a black marginal line. A longitudinal mesial dorsal broad black line transversing segments 3, 4, and 5 continuously in both sexes and showing in short 6th in female; black fringe (or pecten of hairs) on posterior margin of 3rd segment at the side, well developed, black; venter with the sternites dark coloured (fuscous) especially the first; those of 3rd, 4th, and 5th progressively increasing in size and intensity of colour. Ovipositor, with 1st segment (7th abdominal) well developed equal to 6th abdominal, tumid above glossy brownish red with straight narrow margins.

Plesiotypes.—Reg. No. Q.M.D. 3125, 2 males, 2 females: var. *major.* H.T. Reg. No. Q.M. D. 3126.

Food Plants.—These as far as observed comprise only:—*Solanum verbascifolium* Lin. and its close ally, *Solanum auriculatum*, and exceptionally Capsicum (especially *C. grossum,* the giant capsicum), the "chili" of Australia and "pepper" of elsewhere.

Hab.—Coastal Queensland and New South Wales—from Sydney, northwards, extending in the west to Stanthorpe (H.J.) (possibly introduced there intentionally by man) and at Eidsvold (T.L.B.). It moreover has a very wide extra-Australia range. That it should therefore occur in Queensland is not surprising, inasmuch as this extended distribution includes the region of India, Java, and the Philippine Islands.

Note.—This fly, that H. Tryon formerly (1920) distinguished from the so-called "Queensland Fruit Fly" under the name of Solanum Fly, he is now led to regard as being *Dacus dorsalis,* F. Hendel 1912, a member of the *Dacus ferrugineus* Fabr. group and therefore one denominated by M. Bezzi—*Chætodacus ferrugineus dorsalis,* Hendel

("Fruit Flies of the genus *Dacus sensu latiore,* Diptera, from the Philippine Islands"—Phil. Jnl. Sc. XV., No. 5, pl. & 23, 1918). Hendel's description of it, based on a fruit fly from Formosa, is in his paper on the "Genus *Dacus,* Fabr. 1805 (Diptera)—Supplementa Entomologica (I, 18, 3, pls, fig. 1, 1912) and that of Bezzi is embodied in his systematic key to Philippine species of *Chætodacus* (Bezzi M., *op. cit.* supra pp. 17 & 20). This fruit fly is readily distinguished amongst Australian Trypetidæ by morphological features as well as on physiological grounds. According to Bezzi (1916 p. 12) the fruit flies of the "ferruginus group" are the only ones attracted by oil of citronella (Metheugnol), and the present species is one to which this applies in marked degree. Again its injurious relations to fruits is similarly limited here, as elsewhere, to those of a very few plant species, and especially to two Solanums of very widespread occurrence, the only economic one being the chili (Capsicum).

So restricted and exclusive indeed is this plant relationship that, notwithstanding the fruit of several other Solanaceæ—both native and naturalised species, growing here in addition to those named—have been examined, in no instance have they proved to harbour the maggots of this fruit fly—*Chætodacus dorsalis,* Hendel. Howlet F.M. (Bul. Entom. Res. VI., Pt. 3, Pl. XIII., figs, 1 and 2, 1917) figures under *Dacus zonatus,* Saunders—a fruit fly that, as his illustration indicates, has exactly the peculiar black pattern of colour of the mesonotum that characterises the Queensland fly, *i.e.,* a mesial black bar commencing broadly at the fore-border and gradually narrowing to a point on the hind one. However, evidently when Howlet wrote, it had not been recognised that *Dacus dorsalis,* Hendel, occurred in India, and doubtless had been confused previously with *Dacus zonatus* (Saunders) amongst whose food plants the fruits of Cucurbitеceæ had been included.

CHÆTODACUS BARRINGTONIÆ, sp. nov.

Barringtonia Fruit Fly.

Male and Female. Measurements—

Male.—Body 7·5 mm., wing slightly exceeding 6 mm. *Female.*—Including ovipositor 8 mm. (*Note.*—The measurements of several males ranged from 6 to 7·5 mm.—length of body.)

Head.—Horn yellow coloured, occiput with the sclerites outlined with fuscous; frons more than twice as long as broad of almost equal breadth: concave from side to side between s. or, in front a raised area with a low mesial arched keel corresponding in position to the dark central frontal area, its more elevated part being black: ocellar spot black small but distinct, frontal lateral spots indistinct; face almost level along middle line, scarcely ascending beyond depression to mouth border, facial spots subround distinct, gular spots distinct; antennæ with joint 2 rather exceeding joint 1, joint 3 reddish-brown with outer face and end fuscous, arista dark piceous reddish basally, palpi oval reddish-brown; cephalic bristles:—vt. brown s.or 1 and i.or 2 black, ocp. black and 7 in number.

Mesonotum.—Reddish brown with pale golden-yellow appressed pubescence without central pale stripe, but (as seen in oblique light especially) with narrow brown mesial line from almost fore to hind border, and parallel to it on each side a similar line starting above humeral callus and reaching also almost hind-border, curved outwards in front of and inwards at level of suture; scutellum evenly punctured with 2 long terminal bristles, meso-phragma pale reddish-yellow, the posterior third a broad brownish band; calli and stripes yellow, humeral clothed—as in other Chætodaci—with erect white pubescence, meso-pleural the same, ncto-pleural distinct from humeral, supra-alar from suture to p.sa bristle, rounded at each end, and of almost even breadth, hypo-pleural calli, contiguous to meso-phragma; thoracic chætotaxy as follows:—scp. 4 the middle pair shorter, n.pl. 2, pr.sc. 2, s.al. 2 posterior 1 anterior (small), m.pl. 1—bristles all—including scutellar ones—castaneous-brown.

Abdomen.—Rugose punctured with grey depressed pubescence, dorsum with slight mesial impression, segments 1-2 pale-reddish horn coloured clouded with fuscous in the centre along hind-border of segment 1, segments 3, 4, and 5 outwardly dark fuscous, the discal $\frac{1}{3}$ in each pale-reddish horn yellow (exceptionally those segments wholly fuscous above, the yellow being restricted then to hind borders of 3 and 4). Male with pecten of black bristles on hind-border of segment 3 at sides. Female with sternites and ovipositor. . . . .

Wings.—With veins horn-yellow, costal, 1st and 3rd longitudinals with dark bristles, costal cells hyaline and non-colourous, costal-band pale-fuscous, not widening to beyond 2nd longitudinal, narrowly following along end of submarginal cell and becoming gradually obsolete beyond 3rd longitudinal vein: wing fuscous in narrow portion of 1st basal cell in front of 2nd basal; anal fuscous band occupying anal cell and the portion of the 3rd posterior one bounding anal cross vein: in the male fly this unites at the wing-margin with a slight infuscation in axiliary cell: supernumerary lobe in male not much developed, marginal cell very narrow, 3rd longitudinal vein waved, outer portion of 4th distinctly arcuate, small cross vein joins discal cell well beyond middle.

Legs.—Yellow, slightly darkening beyond 1st tarsal joint; tibiæ of 3rd pair piceous on external face; spur of middle tibiæ brown.

Type.—Reg. No. Q.M. D. 3127. Holo- Allo- and 2 Paratypes.

Host.—Fruit of *Barringtonia calyptrata* R. Br. Fam. Lecythidaceæ usually with high infestation (received from J. W. Ross, Horticultural Instructor, Department of Agriculture). *Loc.* Cairns, North Queensland.

CHÆTODACUS MUSÆ, sp. nov. (Plate XXII., fig. 7.

Syn. Dacus nigrofasciatus, Froggatt, *mss.*

BANANA FRUIT FLY.

Male and Female—

Male.—Length 7 mm., wing 6 mm. *Female.*—Length of body with ovipositor, 7 mm., wing 6 mm.

Head.—Brown; occiput pale brown without markings or indistinct brown mark above foramen; vertex-ocellar spot without bar extension laterally; frons, length about twice width with conspicuous series of 3 lateral spots and distinct purplish brown central spot in front (sometimes obsolete), lunule glossy concolorous with head; face scarcely ascending to mouth border, facial spots circular isolated from mouth-border, a small indistinct brownish spot in front of eyes (on jowls); antennæ brown, 2nd joint rather longer than 1st, 3rd joint brown darker—almost black, on outer surface beyond arista, this dark-coloured lighter at base; palps pale-coloured; proboscis brown; cephalic bristles, two pair of weak fronto-orbitals, and generally those of *Dacus* (sens. strict) present, colour dark-brown.

Mesonotum.—Closely punctulate, clothed densely with short yellowish appressed pubescence, general colour reddish-brown. Dorsum black showing indistinctly underlying colour red brown, in front and behind from scutellar to anterior margin, bounded at first laterally by supra-alar stripe then suddenly convexly narrowing towards suture, thence anteriorly parallel sided, emitting on each side at right angles and half-way to noto-pleural suture a similarly coloured terminally rounded stripe. (*Note.*—This may almost separate off as a spot); a patch contiguous in front to meso-pleural stripe, the pectus and infra-alar region dark-brown*; meso-phragma, having a broad yellowish central band widening at scutellar margin, then continuously black on each side downwards behind hypo-pleural calli; scutellum yellow with apical pair of setæ only; yellow markings as follows:—humeral calli, notopleural calli, mesopleural band united with sternopleural calli below, and hypopleural calli—conjoined. The yellow supra-alar band extends from suture almost to scutellum, without narrowing posteriorly. (*Note.*—No yellow band uniting humeral and notopleural calli, as occurring in *D. Jarvisi.* Tryon.) Thoracic bristles—pr.sc. 2, p.sa. 2, a.sa. 1, n.pl. 1, m.pl. 1, scp. 4, all brown.

Abdomen.—Unusually widened with convex sides—especially in female, and uniformly pale orange-brown, also with whitish appressed pubescence; 1st and 2nd segments distinguishable above, 1st brownish at centre and at sides, 2nd with a transverse band at junction of 2 slopes, a line continuous along hind-border of 3rd narrowing at sides united with a lateral brown mark on the same segment that is continued shortly along the hind-border—the interval between the two a somewhat palish band; a very indistinct black longitudinal mesial line traverses 4th and 5th segments; ovipositor, with the sheath (7th abdominal segment) short.

* In a banana fruit fly (var., *dorso-picta,* Tryon) illustrating a varietal condition, we find the dorsum coloured as follows:—A mesial reddish-brown fascia bounded by two parallel black streaks in front of suture, and behind it suddenly widening and extending parallel to suture border. These then either continuing laterally to and along supra-alar yellow stripes, or a red bounded black stripe may separate one and the other; between these, and sometimes united to them, half-way between suture and fore-border on pleuron a spot. In the insect above described the dorsal-lateral black stripes evidently unite to form a single patch.

Wings.—Costal cell—both divisions—hyaline and noncolourous; costal band fuscous, not passing in middle 2nd longitudinal, continues around apex to half-way between 3rd and 4th longitudinals without widening, 1st basal cell above 2nd basal cell also fuscous, stigma included in costal band darker than it; anal stripe embracing anal cell and the portion of anal cross vein bounding 3rd posterior cell—without bulla in male; veins brown, darker when included in fuscous bands.

Type.—Reg. No. Q.M. D. 3128. Holo- Allo- and 2 Paratypes, ex *Musa cavendishi*. Reg. No. Q.M. D. 3129. Holotype, ex Musa sp. (indigenous).

Host Plants and Habitats.—(1) Wild Banana—*Musa Banksii*, R.Br. (indigenous) Cardwell (Dr. T. L. Bancroft), Babinda, North-East Queensland (Becker). (2) Cavendish Banana—*Musa Cavendishi*, Cardwell, Johnstone River, Babinda, Cairns, &c., and Stannary Hills (Dr. T. L. Bancroft).

The so-called "Queensland Fruit Fly" having the cultivated banana for a host, it was formerly concluded that all damage experienced by this fruit was due to it. However, in 1908 W. W. Froggatt submitted an example of the species above described with the intimation that it had been bred from bananas that had come from Queensland. Since then, from 1909 onwards, the same fruit infested with the present fruit fly was met with in both the Cairns and Johnstone River districts, it being reared from specimens therefrom. In "The Banana in Queensland," by A. J. Boyd, Department of Agriculture, Qd., Brisbane, 1911, writing under the heading "Fruit Fly," H. Tryon stated as under: "The fruit fly that is found associated with the banana in tropical Queensland differs from typical *D. Tryoni* in having the dorsum of the prothorax suffused with black, this portion of the body, therefore, presenting an unusual darkening of colour. The abdomen again is differently coloured." *Op. cit.* pg. 26. Early during the present years, Dr. T. L. Bancroft communicated—a matter of much interest—examples of *Chætodacus musæ* bred from an indigenous banana (*M. Banksii*) as emanating from Cardwell; and we have also received the same insect having also this plant's fruit for its host, from Babinda. Our own observations in the districts of its occurrence lead us to conclude that it will puncture the fruit when this is still quite green. It was formerly understood that W. W. Froggatt proposed to name a similar fruit fly received from Fiji—*Dacus nigrofasciata* n.sp.

CHÆTODACUS BANCROFTII, sp. nov.

The Bancroft Fruit Fly.

Male and Female. Measurements—

Male.—Length 7 mm., length of wing 5·5 mm. *Female.*—Length of body and ovipositor withdrawn 7·5 mm., of wing 6 mm.

Head.—Reddish-orange (lighter coloured when dry), occiput yellowish with post-orbital area light-brown; vertex with orbital spot simple; frons about as long as broad of nearly even breadth with whitish pubescence especially on posterior area and at sides to a noteworthy extent, central spot more or less indistinct, lateral spots only posterior indicated; lunule glossy narrowed gradually on each side not dark coloured or prominent; face glossy, little raised only in front of depression, rather short, gular spot wanting; antennæ with joints 1 and 2 subequal, 1 brownish, 2 yellow, 3 joint outwardly and terminally fuscous little exceeding joints 1 and 2; palpi pale-brown with upper margin straight lower convex, sides of gulæ adjacent to mouth-cavity with short hairs, similar ones on sides of tongue; cephalic bristles ver. 4 piceous, s.or. 1, i.or. 2, in both cases black and directed transversely inwards. Oc.p. about 5 black, gular bristle wanting.

Mesonotum.—Reddish-brown but dorsum in great part—especially in female dull black, finely rugose punctate with black patches on other parts and whitish pubescence; dorsum with suture well defined at sides only, the outline of the black area—bounded by a broad red border—proceeds from fore-border in a straight line to level of humeral callus, behind, then is continued lateral in a round-ended extension towards the interval between the notopleural calli, thence bordering the suture curves abruptly outwards and follows the inner arched border of the supra-alar band, being blotched with red in front of the scutellar border, and including red marks behind anterior one. (In the male there may be two red bars separated by a narrow black line in the latter situation, whilst at the scutellum the border may be entirely red with its front margin broken by 2 or 4 cusps of the same colour). Scutellum pale yellow with *a conspicuous dark band above, between the apical bristles* involving surface beneath; mesophragma black with a central yellow broad stripe continued backwards from behind fore-border; pectus on each side between 1st and 2nd coxæ black, the colour extending laterally on mesopleuron contiguous to yellow band in front; calli and spots sulphur yellow, humeral entire, mesopleural stripe almost parallel sided, extending to posterior supra-alar bristle; thoracic chatotaxy.—scp. 4, n.p. 2, s.a. 1, anterior-small, 2 posterior, pt. 1 weak, these chætæ uniformly very dark brown.

Abdomen.—Shortly top-shaped, uniformly orange-yellow as in *C. musæ*, Tryon, with faint brown hue (pale reddish-brown in dry specimens), segments 3, 4, and 5 of subequal length, segment 6 in female about equal to 5, ovipositor very short.

Wings.—Costal cell hyaline uncoloured, stigma long and very attenuated pale fuscous, costa 1st and 3rd longitudinal bristly; costal stripe narrow and indistinct continuous with stigma, filling narrow marginal cell and proceeding along the submarginal border around apex to just beyond 3rd longitudinal without widening; 1st basal anterior to 2nd basal cell also fuscous; anal stripe formed by darkening of anal cell a wide portion of 3rd posterior and adjacent inner extension of anal; no darkening at end of 5th longitudinal.

Legs.—Yellow, tibiæ darker yellow, tarsi hyaline.

This fruit fly is readily distinguished by the black figure occupying almost the entire dorsum of the mesonotum—one that recalls that of the Indian species—*C. diversus*, Coquillet, and melanic varieties—as described—of *C. persicæ* Fabr.; its almost uniform pale reddish-brown rotund abdomen, however, distinguished it from either. Its scutellar dark brown is again characteristic.

Type.—Reg. No. Q.M. D. 3130. Holo- Allo- and 1 Paratype.

Habitat and Host.—The examples under review were reared from *Cudrania javanensis*, Trecul, *var.* Bancroftii (Urticaceæ), but it also occurs in this association in districts as wide apart as the Brisbane and Herbert Rivers. It is noteworthy that the maggot of this fly acquires the yellow colour that—as is well known—is a feature in some of the tissues of its plant host. The writer is indebted to the Queensland Board of Forestry for the specimens examined for the purpose of this description and that were from the Gympie district, and particularly so to Deputy Forester F. C. Epps and two of the field officers. It is the most handsome of our Trypetidæ and is dedicated to Dr. T. L. Bancroft, whose co-operation also has been so signal and so continuous.

CHÆTODACUS JARVISI, sp. nov. (Plate XXI., fig. 6).

THE JARVIS FRUIT FLY.

Male and Female. Measurements—

Female.—Length of body with ovipositor, 7·5 mm., of ovipositor 2 mm., slightly more, of wing 6 mm.

Head.—Pale reddish-brown, lighter coloured beneath occiput, pale brownish-yellow without markings (in some examples the sides of the foramen, bearing a white fringe of hairs, fuscous); vertex, without marking bordering black ocellar spot; frons dull, about twice as long as broad, slightly widening anteriorly, central spot on low convexity present, lateral black spots obsolete; lunula glossy paler than frons; face little prominent in front with usual 2 black spots; palpi oblong, jowls silvery grey, sub-ocular spot absent; cephalic bristles as follows:—vt. 4 brownish-yellow, s.or 1 and i.or 2 black, ocp. *wanting*, bristle on jowls pale brown.

Mesonotum.—Surface finely punctured, clothed with short greyish pubescence, suture non-continuous, reddish-brown with a mesial and 2 lateral narrow brown stripes, the former not continued to scutellum, enclosing a wide longitudinal greyish band; pleura reddish, a dark patch on mesopleuron in front; yellow calli, spots, and stripes, as follows:—(1) humeral callus entirely, (2) notopleural callus, (3) hypopleural callus double, (4) *a broad band between* 1 *and* 2 *making with them a continuous notopleural stripe*, (5) mesopleuron stripe continued by a spot on sterno-pleuron, (6) a parallel-sided supra-alar stripe extending from suture almost to scutellum. Mesonotal bristles as follows:—sa. 4, pr.sc. 2, n.pl. 2, m.sp. 1, p.sa. 2, a.sa. wanting; scutellum yellow with 2 apical bristles. All the bristles yellowish-brown (or castaneous); mesophragma red with the sides broadly fuscous.

Abdomen.—Broad, paler than mesonotum, similarly pubescent, segment 1 brown, *segment 2 with a broad transverse white band extending to sides bounded in front by a black outwardly narrowed line, and behind along the base of the 3rd segment by a wider evenly-broad black band also*; a longitudinal black mesial band, broken at segmental incisures, continued from latter through 3rd, 4th, and 5th segments. (Male with pecten—present in Carreya var.—of black bristles at the sides of hind border of segment 3). Ovipositor long—when extended—equalling segments 3, 4, and 5; basal section brown glossy and swollen at base (tumid upper surface), 2nd equal to basal one above; venter very pale coloured, except sternal sclerites 4, 5, and 6 that are brown.

Wings.—Glossy, veins pale-horncoloured, small cross vein distant from hind cross vein rather further than length of latter (*i.e.,* length between small and hind cross vein exceeding length of latter). Costal cell with both divisions hyaline colourless; costal brown band including stigma, occupying marginal cell, and faintly tinting just beyond 2nd longitudinal submarginal one, and bounding it outwardly along wing-margin and extending to half-way between 3rd and 4th longitudinal, ending abruptly after first widening, thus forming *an apical dark wing patch;* anal brown band occupying anal cell and extending along outer 3rd posterior cell adjacent to anal cross vein extension; 1st basal cell in front of 2nd basal also infuscated.

Type.—Reg. No. Q.M. D. 3131; 1 female. Reg. No. Q.M. D. 3132; Holo- and Allotype, var. Careya.

Habitats and Hosts.—Hab. 1 Stanthorpe, South Queensland, altitude 3,000 ft., taken at large and reared from maggots infesting both pear and quince (H. Jarvis).

Hab. 2, Bowen (1 Rainford), Rockhampton District and Burnett Heads (Dr. T. L. Bancroft), grossly infesting the fruit of *Careya australis* (Sapotaceæ) (var. *Careya* Tryon).

Hab. 3, Howard, Burrum River; captured (Prest).

Note.—This fruit fly is readily distinguished from other species of *Chætodacus* in having a broad yellow longitudinal band uniting the humeral and notopleural calli. Moreover, it is peculiar in the livery of the 2nd and 3rd abdominal segments—the white black bounded transverse band being characteristic. Again it is *without both post-orbital and anterior supra-alar bristles,* a feature only found in *C. cucumis,* French —a fruit fly that, however, has its own very special features.

The present species, again, was originally regarded as being an insect that had the sapotaceous plant *Careya australis*—locally known as Cockatoo Apple or "Wild Guava," and whose fruit may be grossly infested by its maggots, exclusively for its host. And, although, from specimens received from 1912 onwards there was evidence of its numerous occurrence with this plant association in the Bowen, Rockhampton, and Burnett Heads districts, no suggestion had arisen that in any one of them did it attack any of the cultivated fruits grown therein. In 1922, however, H. Jarvis submitted a fruit fly that, he pointed out, was very distinct in its markings from *C. Tryoni,* Frogg., or from any of its varieties—a fruit fly that he had reared at Stanthorpe sparingly from both peaches and apricots, grown there.

This insect became known as the "Jarvis Fruit Fly," and being injuriously related to deciduous fruit its discovery was regarded as of considerable interest. The Jarvis fruit fly, then, having thus been met with in a district very remote from any known habitat of *Careya australis,* and being both larger and of a general darker colour than the fruit fly yielded by it, it did not at first present itself as a probability that these two insects were identical or even allied. However, on H. Jarvis—who had meanwhile received specimens of the former from Dr. T. L. Bancroft—instituting a closer comparison, that they were really representatives of a single fruit fly species, was the conclusion he arrived at. In fact, on examining them closely no features of distinction, except those above mentioned, have been remarked. This interesting discovery accordingly suggests that the Jarvis fruit fly has, as an addition to *Careya australis,* a second indigenous fruit-bearing tree for its host, *i.e.,* one yielding sustenance for its maggots, or that *Careya australis* has a far more extended range of occurrence than is at present known to occur.

Gen. BACTROCERA, Guerin-Meneville 1838.

BACTROCERA CAUDATUS (Fabr.) *aff.* (Plate XXIII., fig. 9).

CUCURBIT FLY MIMIC.

Syn. Dacus caudatus Fabricius Syst. Antl. 276, 16, 1905.

Syn. Dacus caudatus, Wiedemann, *pars.* Auss. Zweifl, II., 518, 8, 1830.

Syn. Dacus caudatus, Fabr. de Meijer Tijdschr. v. Entom, LI., 179, 5, 1908.

Syn. Bactrocera caudata (Fabr.) Bezzi, Indian Trypaneids, p. 97, Pl. VIII., fig. 8 (wing), Mem. Ind. Mus. III., 1913.

Other references, vid. Bezzi M. l.c.).

Measurements—

Female.—Length of body 8 mm.; of wing 8 mm.

Head.—Pale brownish-orange, glossy; occiput, lateral convex portion posterior to eyes, yellowish horn coloured, central portion yellowish-brown with narrow brown lines defining sclerites, these being parallel continuous with inner border of eyes, two curved inwards from middle of each of these lines and meeting at occiput, and one on each side just behind this point obliquely to eye; vertex-spot black very distinct extending slightly backwards from hind ocelli; frons—about twice as long as broad, slightly arcuate outward at sides, lateral areas rather wide, punctulate pubescent, central area impunctate glabrous, slightly swollen anteriorly towards central spot, latter composed of a narrow crescentic black portion with a sub-circular orange mark in its concavity in-front, an indication of a narrow dark line between ocellar and frontal spots; lunule—narrow formed by two small convexities fuscous; face—in form rather long equilateral triangle, nitid, convex as usual along middle line, portion in front of depression short slightly sloping upwards to mouth border, facial spots rather small but distinct, oval, remote from mouth-border; gular spot touching eye rather indistinct, cheeks narrow, dull; mouth concavity marked by a fine line, within which is a narrow pale band and then a fuscous wider one, the latter interrupted in middle, but very distinct; palpi, curved yellow; antenna joint 2 a little longer than 1, latter parallel-sided, stout, former narrowing proximally, joint 3 uniting closely with 2, basally yellow and glossy, beyond greyish, arista fuscous with basal portion yellow; cephalic chætotaxy vt. 2, 2, p.oc. wholly wanting. (*Note.*—Short pale hairs of pubescence might be mistaken for them), orb—2 superior and 2 inferior, latter weak, no 3rd one discernible, all black.

Mesonotum.—Pale reddish-brown, finely rugose punctate and with yellow appressed pubescence; from just before suture and reaching level of upper supra-alar bristle a mesial yellow bar starting as a point and widening posteriorly, also an ill-defined yellow patch bordering the suture in-front on each side; a pale greyish-brown mesial longitudinal scarcely evident band and black markings as follows:—On each side a short bar in front of suture, opposite interval between humeral and noto-pleural calli, widely broken at suture and thence continued by a second broader band of same colour along the upper border of supra-alar yellow band as far backwards as is mesial yellow stripe, meso-pleuron narrowly in-front and a spot on sterno-pleuron also fuscous; mesonotal yellow calli as follows:—humeral large occupying two sclerites, noto-pleural small, widely separate from latter but contiguous above to meso-pleural; latter large occupying almost mesopleuron, sterno-pleural contiguous to latter also large, hypo-pleurals conjoined, sub-equal isolate; supra-alar band not very distinct (in type specimen) narrowing posteriorly; scutellum rather broad, uniformly yellow; mesophragma with central third pale reddish-brown, outer thirds dark fuscous or black—the latter colour not extending to hypo-pleural region, the line separating central and lateral areas convex inwards. Mesonotal chætotaxy as follows:—sc. 4 sub-equal. hu. wanting, pr. su. wanting, n.pl. 2, n.pl. 2, m.pl. 1, inf. al. 1, s.al. 1 anterior 2 posterior, p.sc. 2. *Scutellar bristles,* 2 pairs—an *apical* and a *lateral;* all bristles black.

Abdomen.—Elongated (bred and ill-fed specimen), yellowish, punctuate with yellow-golden appressed pubescence, and with black markings, segments 1 and 2 well defined; segment 1 with transverse rugæ above distinct, a broad black band occupying anterior half of disc and sides wholly (*i.e.*, all except central portion); segment 2 with black patch in the middle crossing hind part of anterior third not extending to sides, also a narrow dark grey band along posterior border, the yellow colour paler than elsewhere; segment 3 a dark narrow band along fore-border widening at sides occupying there one-half length; from latter band a longitudinal also dark one extends centrally through 3rd and 4th and 5th segments, segment 4 almost wholly fuscous at sides and segment 5 only towards its under surface, the dark area narrowing posteriorly; segment 6 (base ovipositor) tumid, glossy almost glabrous above, ovipositor stout.

Legs.—Femora horn-yellow gradually passing to orange-yellow distally, tibiæ and tarsi orange-yellow, hind pair light fuscous distally, terminal spur of middle tibiæ castaneous, femora of first pair without bristles.

Wings.—Veins orange-brown except where within dark markings; costa and 1st and 3rd longitudinal veins bristly; 2nd basal cell rather elongated more than twice as long as broad, slightly narrowed proximally, costal cells transparent and colourless, the 1st only slightly pale-yellow; costal fuscous band to 2nd posterior (*i.e.*, not filling sub-marginal cell except terminally where it bounds it), sub-marginal cell with pale yellow suffusion), terminating indefinitely about half-way between 3rd and 4th longitudinal veins, an oval fuscous patch occupying broadly for some distance the end of the 3rd longitudinal vein and attaining wing margin (as in *C. cucurbitæ* Coq. and its allies). Outer sector of 5th longitudinal and hind cross conspicuously margined with fuscous, this colour not continued outwardly along small cross-vein (as it is in *C. cucurbitæ* Coq.); anal cell, and its extension, and adjacent portion of 3rd posterior one widely fuscous and forming an anal band.

Plesiotype.—Reg. No Q.M. D. 3133; one male.

Host.—Fruit of *Bryonia laciniosa* (Cucurbitaceæ), H. Jarvis.

Locality.—Eidsvold (Dr. T. L. Bancroft) and Eumundi (Hall).

Systematic Relations.—M. Bezzi in his "Fruit Flies of the genus *Dacus* sensu latiore (Diptera)," Phil. Jnl. Sc. xv., 5th November, 1919—in treating of that group of *Chætodacus,* Bezzi 1913, that he distinguishes as comprising the larger fruit flies having, *inter alia,* "the 4th abdominal segment without complete black cross band or rarely with a very narrow one and the last two segments of the abdomen with a black longitudinal middle stripe" divides it into two sections—one characterised by the "scutellum with one pair of bristles, the apical one," and the other by "the scutellum with two pairs of bristles, the basal and apical (ones) being equally developed" (*op. cit.*, pp. 18 and 19). Amongst the former he includes *Chætodacus cucurbitæ,* Coq.; that, however, is exceptional amongst them in possessing "three pairs of lower fronto-orbital bristles" and a "bright yellow middle (meso-notal) stripe beyond the suture." These two exceptional characters of *C. cucurbitæ,* Coq., are, however, present in each of the species of Philippine Island fruit flies comprised in his second group—insects with 4 scutellar bristles—from which he excluded it. Moreover, they are also exhibited in the above-described Queensland species. However, although it has, in common with them, these two pairs of scutellar bristles, it differs from each in having the broadly infuscated hind cross-vein; but not so if—differing from Bezzi—

we follow de Meijere (Tijdschr. voor. Ent. 57, 191) and regard one of this 2nd group—*C. caudatus*, Fabr. (1805)—as being so endowed. Like the latter, again, it has "black patches on the back of the mesonotum behind the suture (although, in addition, others, as above described, in front of it). The type locality of Fabricius' species (*caudatus*) is, however, Java—of whose fruit flies the Dutch dipterologist is writing also, not the Philippines. Again, the description (*vid.* Froggatt, W. W., *l.c.*), that he gives of this fruit fly being brief, and neither an example of *C. caudatus* (Fabr.) Meijere from Java, nor one of *C. caudatus* (Fabr.) Bezzi, from the Philippine Islands, being before us, it would seem hazardous perhaps to identify—as we now do—the Queensland fruit fly with the one from the type locality so named, but such risk may be entertained.

BACTROCERA PULCHER, sp. nov.

Head.—Pale-yellow; occiput almost wholly black nearly to vertex, leaving a yellow continuous post-orbital band; frons yellow, frontal spot large and with short fuscous pubescence, rather broad, length less than half greatest width, slightly widening in front; lunula wide, without central groove, pale hued, face with central area very flat-white, not raised towards mouth-margin, facial black spots non-circular—drawn out anteriorly, antennæ reaching beyond front border, second joint, with numerous black hairs, about twice the length of first and two-thirds length of third joint, third joint brown, fuscous on outer face, arista simple black with yellow basal portion; palps (not observed), cephalic bristles as follows (*Note.*—Dropped out, except postocular and anterior fronto-orbital, that are black), vt., ocp., s.or. 1, i.or. 3: the latter anterior fronto-orbitals three in number, post-occipitals placed in yellow band.

Mesonotum.—Black from anterior border to scutellum, rather coarsely closely punctured, pubescent: a spot on lower side of humeral callus, and a patch from just in front of suture, including supra-alar stripe and wing origin red. Calli and spots present as follows:—Humeral hypo-pleural calli conjoined contiguous to scutellum, supra-alar band very short extending only half-way from suture to hind border; scutellum yellow with two bristles and with a dark basal border; mesophragma black—dull; chætotaxy as follows:—Prescutellars 2, scapulars 4, supra-alar anterior present—black, and otherwise as in Chætodacus spp.

Legs.—Coxæ (black), femora and tibiæ red, former with erect, latter with depressed pubescence, tarsi yellow, ungues black.

Wings.—Conspicuously 2 banded with fuscous, veins brown except those included in markings, these being black. Second basal cell elongate, just exceeding second basal cross-vein (hind cross-vein), small cross-vein sigmoid, distance between it and hind cross-vein well exceeding length latter, third and fourth longitudinal veins with evenly curved outer sections; markings, a broad fuscous marginal band filling costal cells, stigma, marginal and outer half of sub-marginal cells to wing-tip: basal cell above second basal cell also fuscous; a broad triangular fuscous patch from outer wing margin, and wholly including hind cross-vein, to third longitudinal vein and including and passing beyond small cross-vein: and anal stripe including anal cell and anal half of third posterior cell.

Abdomen.—Black coarsely densely punctured—punctures tending to form rugæ; basal portion (joints 1 and 2) with white pubesence, remaining segments pubescence yellow: a conspicuous broad yellow band along hind border of second segment slightly wider laterally then narrowing and extended to sides, pectens of bristles on hind border of segment 3 present. Venter, except a marginal light-colourd band black.

Host.—Not ascertained. The fly observed settled on a fallen orange (Hall).

Habitat.—A single specimen from Glass House Mountain, Southern Queensland, 24 and 24, Col. Dep. Agr. and Stock Reg. D. 1084 [Type].

Note.—This fruit fly in having three inferior fronto-orbital bristles agrees with *C. cucurbitæ* (Coquillet), but the bright-yellow middle stripe beyond the suture of the mesonotum of the latter not noticeable. It may, however, be within the varietal range of that widely distributed species, notwithstanding the highly developed fuscous markings of its wings.

Gen. DACUS.

DACUS CUCUMIS (French), Plate XXI., Fig. 5.

QUEENSLAND CUCUMBER FLY.

Syn. 1907 *Dacus tryoni,* Frog., *var.* cucumis, French. Journal Dept. Agr., Vict., 1907, May.

Syn. 1909 *Dacus tryoni,* Frog., *var.* cucumis, Frogg. "General Account of Flies—Trypetidæ," 1909, pp. 12-13.

Syn. 1910 *Dacus cucumis* Fr. "Notes on Fruit Flies (Trypetidæ)," Proc. Lin. Soc., N.S.W., XXXV., 4, p. 886, Nov., 1910.

Syn. 1913 *Dacus cucumis* (French.), Bezzi. "Critical Review of Oriental and Australian Trypaneidæ hitherto described (in Indian Trypaneidæ F. Flies), Mem. Mus. Ind. (iii.), p. 70, 1913.

Note.—In no case do these references cover adequate description of the insect.

Male and Female Measurements.—Male, length of body 6 mm., of wing 6 mm.; female with ovipositor 8 mm., ovipositor 1 mm., wing 7 mm.

Head.—Brownish horn-coloured; occiput yellow horn-coloured part bordering eyes behind whitish central area swollen above, frons of almost even width with central area, anteriorly tumid with frontal yellow spot and brown dark spot in-front, lateral spots wanting; lunule compressed to form a narrow ridge; face little prominent in centre anteriorly, spots circular well within oral-margin; cheeks wide beneath eyes, gules pubescent; antennæ with first and second joints subequal, third scarcely exceeding face, arista long without cilia and basal one-third or more pale; palps yellow not widened apparently terminally curved; proboscis very hairy; cephalic bristles, p.vt. wanting, vt. 4, o.cp. indistinct, weak, and pale, fronto-orbitals, black—s.or 1; i.or. 3 (1 and 2) (as in *D. cucurbitæ,* Coquillet), the latter two close together in front—small and difficult to detect, gular-bristle reddish.

Mesonotum.—Pale reddish-brown with appressed golden pubescence finely rugose punctate præsutural area with two pale longitudinal bands defined laterally and separated by narrow brownish lines, suture narrow about one-third dorsum not involved in it, calli and marks both very pale-yellow to white as follows:—Dorsum with a short mesial callus extending backwards from suture two-thirds distance towards scutellum gradually broadening and rounded terminally, humeral callus well separated from notopleural callus, mesoplural stripe broad, hypopleural double, supra-alar band with upper border almost straight, lower excavated, posterior end rounded and embracing hind supra-alar bristle; scutellum broad, two pair bristles, apical ones black, lateral brown, rather more coarsely punctured than is mesonotum; mesophragma impunctate uniformly brown, bounded laterally by an indistinct yellow band and dark line; thoracic bristles, scp. 4 dark-brown, pr.s. o., hm. o., n.pl. 2, all dark piceous, darker than scapular, m.p. 1 pale-brown, sa. 2 posterior, the anterior wanting* (two or three small bristles at root of wing in front), scutellars 4 dark, fuscous almost black, basal about half-terminal.

Wings.—Rather long, veins yellow, costal vein, first longitudinal and third longitudinal, yellow; costal cells colourless, transparent; costal stripe or border includes paler stigma and involves narrow marginal cell, and wing border evenly of submarginal cell, ending without enlargement or narrowing at wing tip between third and fourth longitudinal; *an indistinct light fuscous band along both sides of the terminal division of fifth longitudinal vein,* beyond hind cross-vein, first basal cell in front of anterior border of second basal cell fuscous; an anal streak occupying anal cell and its narrow extension, that reaches about half-way to wing-border, and also continued with a faint infuscation on the side of the third posterior cell.

Legs.—Uniformly pale-yellow, the femora of lighter hue clothed with tawny pubescence more dense on tibiæ above, end-spur of middle tibiæ short and black.

Abdomen.—Finely punctured surface with golden appressed pubescence, dorsum first or basal segment smooth, yellowish horn colour (sometimes a broad marginal white band along hind border of each of succeeding three segments). Venter pale-coloured, whitish.

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* Individual examples rarely possess a weak short anterior sa. bristle—usually occurring on one side mesonotum only.

Male.—Abdomen with hind lateral border of third segment apparently without pecten of vibrissæ. The several segments well defined.

Plesiotypes.—Reg. No. Q.M. D. 3134.

Host.—Cucurbitacæ—i.e., cucumber, pumpkin, vegetable marrow, melon—especially damaging the fruit of these when newly formed (C. N. Collins); also tomato.

Hab.: Bowen, Yeppoon, Howard, Brisbane Qd. (H.T.), Coonamble N.S.W. (Froggatt, 1909-12).

Note 1.—This fruit fly was first named by C. French in 1907 merely as a variety of the so-called "Queensland Fruit Fly" *C. Tryoni,* his brief account being based on specimens reared from Bowen (Queensland) cucumbers received in Melbourne during September of the previous year. W. W. Froggatt adopted this determination in 1909, but in the following year, after having forwarded specimens to both Bezzi and Coquillet, favoured their view and regarded it as a distinct species. M. Bezzi on his part confirmed its specific rank in 1913. In our "Report of the Entomologist, Department of Agriculture, Queensland, 1910-11," after reference to the existence of this fruit fly at Melbourne, Victoria, in cucumbers from Bowen in October, 1906, as above alluded to, it is further stated:—"The occurrence of this fruit fly in our cucumbers was not confirmed by this office until 26th November, 1910, when the insect had recently been found, in numbers in the same class of vegetables, from Bowen; also by the New South Wales authorities. A few days earlier, however, this office had reported having reared it from tomatoes from the same fruit-growing district."

Note 2.—It might be considered that *Dacus cucumis* (French) might prove to be a variety of the very variable *C. cucurbitæ,* Coq., a fruit fly also apparently occurring in Queensland. However, it is very different from it, and in fact it exhibits noteworthy features that may be regarded as adequate to place it in a separate genus from that containing *C. cucurbitæ. These features comprise two pairs of scutellar, absence of pre-scutellar, absence of anterior supra-alar, and of posterior ocular bristles.* At the same time it possesses, in common with *C. cucurbitæ,* three anterior frontal ones.

Bezzi, writing in 1916 on another fruit fly associated with the fruit of Cucurbitaceæ elsewhere, *D. brevistylus,* Bezzi, states: "Amongst other Oriental and Australian (species of) *Dacus sens. str.* are only it and *D. cucumis,* French (1907), from Queensland which has, however, four scutellar bristles, a thing which has never been observed in any Ethiopian species of the genus. (Bull. Ent. Res. vii., 101). Bezzi has described since this utterance three Philippine Island species of *Chætodacus,* each of which has four scutellar bristles, apparently a feature also in a fourth:—(1) *C. mundus,* (2) *C. tetrachætus,* (3) *C. scutellinus,* but of these the No. 1 is said to have three lower orbitals, whilst No. 2 and No. 3 have only two of lower orbitals, but none of them has either the anterior supra-alar or prescutellar bristles absent, and so fails to preserve the characteristic features of our *C. cucumis, Fr.* (Phillip. Journ. Sc., xv., 5, Nov., 1919). The Queensland insect is, therefore, a somewhat exceptional species of *Dacus.*

DACUS SIGNATIFER, sp. nov.

Rainford's Fruit Fly.

Measurements—

Female.—Length of body, including ovipositor, 7 to 7·5 mm. Length of wing 6 mm.

Head.—Uniform pale brownish-yellow or horn-colour; occiput without markings, a row of minute setæ on borders of occipital foramen; vertex with ocellar spot distinct, but not traversed by a dark bar; frons slightly narrowing towards face, an orange-yellow spot in centre, reaching backwards to first of anterior fronto-orbital bristles; frontal spots indistinct; lunule crossed with a few little striæ; face ascending slowly —if at all—to border of mouth—a central æquilateral flat area, facial spots distinct rounded and remote from mouth-border; antennæ-joints 1 and 2 paler, former rather shorter than latter; palps light-coloured almost parallel-sided, oblong, not widening distally; cephalic bristles, vt. 2 pairs stout black, pvt. and oc. wanting, s.or apparently obsolete (? fallen out), i.or. 2 short and weak or obsolete, oc.p. absent entirely.

Mesonotum.—Pale reddish-brown with appressed golden pubescence, a greyish fascia on each side of a narrow mesial line; *a pale broad white callous bar down centre* falling short of both fore (ending about level with humeral calli) and hind borders narrowing gradually anteriorly rounded behind, a supra-alar stripe from suture to posterior supra-alar chæta, not reaching scutellar border, humeral, noto-pleural, meso-pleural, and hypo-pleural pale yellow or whitish calli or bands, mesa-neural united with sterno-pleural below; scutellum yellow *with both apical and basal bristles,* basal pair very short and difficult to discern; thoracic bristles, scp. 2 pairs black median the shorter, pr.sc. wanting, n.pl. 2, p.sa. 1, *a.sa. wanting.*

Legs.—Horn-yellow, tarsi paler, the short spinelets at the end of the tarsal joints, and spine at end of third tibia black.

Wings.—Hyaline costal cells colourless, costal band pale fuscous—including stigma marginal cell, outer border of submarginal narrowly to half-way between 5th and 6th longitudinal veins; an oblique anal stripe, occupying anal cell and its extension, and adjacent portion of 3rd posterior cell; male with a supernumerary lobe defined by indenture where anal nerve meets wing border.

Abdomen.—Pale rusty-yellow (pale yellow-brown) with appressed golden pilosity, segments 1 and 2 demarcated with a broad whitish band, contiguous to hind border and occupying posterior half of segment 2; *a conspicuous well-defined longitudinal black spot pointed anteriorly in centre of dorsum of segment* 5 (in some individuals an isolated black point on each side of it, sometimes reduced and forming ill-defined blotches); female ovipositor-joint 1 (6th abdominal segment) glossy, joint 2 (7th abdominal) sub-equal when exserted; male with pecten of cilia on each side of hind-border of third segment.

Note.—The possession of 2 pairs of scutellar bristles, and of the meso-notal central vitta associates this species with *D. cucumis*, French. The present insect also lacks the anterior supra-alar bristle and post-orbital bristles in common with this species and *C. jarvisi*, n.sp. The absence of the infuscation at the end of the 5th longitudinal vein distinguishes it, however, from the former, and the colour scheme of the abdomen from both—especially the presence of the black spot implied in the term *signatifer*.

Types.—Reg. No. Q.M. D. 3135. Two females.

Host.—Fruit of *Capparis laurifolia*, R. Br.

Hab.—Bowen, on east coast, bred from the fruit of the local *Capparis laurifolia*—one that is purplish coloured, January, 1915 and 1926. (E. H. Rainford.)

DACUS NIGER, sp. nov. (Pl. xxiv., fig. 14.)

The Small Black Fruit Fly.

Male and Female. Measurements—

Length of body with ovipositor 5 mm., of wing 4 mm.

Head.—Brownish-yellow and black; occiput black except only an even narrow pale-yellow hind-orbital margin; frons pale-yellowish, length rather more than twice width, very slightly widening anteriorly, central spot large brownish, lateral series of 3 spots the same; lunule pale-yellowish, its central area slightly inclined from depression towards fore-border, facial black spots almost contiguous to latter, cheeks linear; antennæ slightly exceeding face and carried away from it, joints 1 and 2 sub-equal brownish, former with very short black spinelets at end—latter with a single larger one, joint 3 reddish exceeding 1 and 2 and outwardly infuscated, arista longer than it simple; mouth-border white; palps broad orange; proboscis brown; cephalic bristles black and as follows:—vt. 4, s.or. 1, i.or. 2—well-developed, gular 3 or 4 short and 1 longer, oc.p. about 7.

Mesonotum.—Wholly black, notum and pleura alike, finely closely punctured and with short greyish-white pubescence, a broad, dark-greyish indistinct uninterrupted bar on each side of the middle line above, comprised of a lancolate portion in front of the suture, and of a club-shaped one behind; the calli, spots, and stripes lemon-yellow and as follows:—humeral callus, noto-pleural, meso-pleural, hypo-pleural all distinct, the sterno-pleural callus and the supra-alar band wanting; the scutellum black and yellow, having a narrow black basal stripe occupying it anteriorly, and in its centre a broad parallel-sided black band occupying nearly $\frac{1}{3}$ width and attaining laterally the apical bristles, but falling short of the hind-border, each side of it beyond being broadly occupied with yellow; meso-phragma entirely black, this colour on each side merging with that of the hypo-pleural calli; thoracic bristles—all black—as follows:—*Scutellar bristles* 4—both an apical and a lateral pair, the former the longer, sc. 4, the inner the shorter, pr. sc. 2, pl. 1, m.pl. 1, a.sa. 1, p.sa. 2, pt. 1.

Abdomen.—Slightly stalked, sub-rotund, black above and beneath, above with whitish pubescence; on the dorsum of segment 2 and wholly contiguous to its hind-border, 2 white transverse bars, separated at the middle line, convex in front, narrowing and terminating laterally; male apparently without pecten of bristles on hind-border of segment 3 at sides; ovipositor very short; halteres white.

Wings.—Almost without markings, 2nd basal cell length nearly twice width, marginal cell very narrow, 4th longitudinal vein with part beyond hind cross vein unusually arcuate, the extension of anal cell falling short of wing margin by its own length; veins yellowish, especially distally, suffused with fuscous; costal, 1st longitudinal and 3rd longitudinal veins with the usual black bristles; costal band almost obsolete, costal cells hyaline and colourless, stigma very pale fuscous; *marginal cell with fuscous hue just traceable;* narrow portion of 1st basal cell and anal cell colourless, *no anal band.*

Legs.—Femora and tibiæ of 1st pair horn-yellow, former with numerous erect black hairs throughout their extent—those of the under surface the longer; tarsi pale-brown with short black bristles and 3 longer inter-ungual ones, middle legs with trochanters black, femora horn-yellow, tibiæ infuscated with brown, and with terminal bristle black, tarsi whitish, 2 short black spines at the end of 2nd tarsal joint, others with shorter similar ones; hind legs with coxa, the end of femur broadly, and tibia black, tarsi whitish and with short black spines.

Type.—Reg. No. Q.M. D. 3136. Holo- Allo- and 1 Paratype.

Host.—The fruit of the indigenous tree, *Symplocos Thwaitesi,* F. v. M. Fam. Styraceæ (Gympie District).

Hab.—Cleveland, Southern Queensland, a single specimen, April, 1894, found in a fruit fly lure (S. Wort); Gympie District as above (C. F. Evans).

This small black Trypetid fly with almost plain (unmarked) wings is very unlike the commoner species of Australian fruit flies. Examination, however, fails to discover any features denotive of a genus generally distinct from *Chætodacus.* Its small size associates it with the lesser of the species of *Dacus sens. strict.*

Gen. CERATITIS, Macleay (1829).

CERATITIS CAPITATA, Weidemann.

Plate XXII., Fig. 8.

MEDITERRANEAN FRUIT FLY (AFRICAN FRUIT FLY).

Syn. *Trypeta capitata,* Wiedemann, C. R., 1824.

Syn. *Ceratitis citriperda,* Macleay, W. S., 1829.

Syn. *Petalophora capitata,* Macquart, J., 1835.

Syn. *Ceratitis capitata* (Wied.), *var.* hispanica, Breme, F. D., 1842.

Syn. *Ceratitis capitata,* Guerin-Meneville, F. E., 1843.

Syn. *Petalophora hispanica,* Rondani, 1870.

Syn. *Halterophora hispanica,* Penzig, 1887.

Syn. *Halterophora capitata,* Tryon, H., 1897.

Syn. Orange Fruit Fly (Mosca del arance), Martellig, 1910 (*vid.* Froggatt).

Syn. "Mediterranean Fruit Fly," Lea, A. M., 1899.

The binomials in each case were used by other writers subsequent to the dates named.

When in March, 1897, Tryon published his identification of a fruit fly that had then recently appeared in Western Australia as the species under consideration, he gave a bibliography relating to it (*vid.* Journal, Bureau of Agriculture, W.A., March, 1897, p. 1186). Subsequent to this bibliographies relating to fruit flies generally have considerably augmented the list.

Thus F. Silvestri (Territory of Hawaii Divis. Entom. Bul. 3 Honolulu 1914), in his "Report of an Expedition to Africa in search of Natural Enemies of Fruit Flies," and under the heading "Bibliography" (*Op. cit.,* pp. 131-146), specifies upwards of fifty-four brochures relating to this insect as is generally indicated by their titles. The same bulletin also gives an extended account of *Ceratitis capitata* (Wiedm.), the fullest in fact that has appeared (*Op. cit.,* pp. 42-61, pl. 1). W. Froggatt writing in 1899 ("Notes on Fruit Maggot Flies," Ag. Gaz., N.S.W., x., 500) succinctly described this fly also. Again, W. B. Gurney has fully treated of the insect from the standpoint of the economic Entomologist (*vid.* "The Common Mediterranean Fruit Fly, *Ceratitis capitata,*" Agr. Gaz., N.S.W., 1910, pp. 30-33, and 1912, pp. 11-15, pl. ii.), and more recently still E. A. Back and C. E. Pemberton have issued two important papers concerning this fruit fly (*vid.* Journ. Agr., Res. III., No. 4, pp. 311-330, and No. 5, pp. 363-374, 1915).

Queensland Habitat (?).—The former Government Entomologist, New South Wales, states:—"For a long time it was believed that it (*Ceratitis capitata,* Wied.), was not to be found in Queensland and, although from what I can learn it is not common, yet it is found in Queensland fruit, and I have specimens from Brisbane." (Froggatt, W. W., Report, 1908-9, p. 104, 1909.)

C. French, in the same year, 1909, in which Froggatt's testimony appeared, wrote:—"No less than sixty adult specimens have been reared from two specimens of the bitter or seville orange which have been sent (to Melbourne) from one of the northern parts of Queensland." Handb. Des. Ins. Vict. IV., *s.v.* Mediterranean Fruit Fly, *Halterophora capitata* (p. 35).

However, Mr. Froggatt's statement is quite consistent with the origin of the specimens in both the cases of its occurrence referred to by him, finding an explanation in the fact that not infrequently during the season when fruit is received here from Sydney, it harbours *Ceratitis capitata* fruit fly maggots, a remark that is especially true of oranges, and hence adult flies can be secured in numbers (on rearing the maggots to maturity), and so virtually may come from Brisbane without being actually endemic there.

This would, too, apply to C. French's observation if well founded; but in the same publication cited, in which it is made, we are informed "The seville oranges were from Sydney" (French, C., *op. cit.*, p. 32). The Mediterranean Fruit Fly infested bananas and oranges, arriving at Melbourne from Queensland, as alleged, on 14th August and 19th September, 1909, may be similarly accounted for.

Personally we have never seen an example of this so-called "Mediterranean Fruit Fly" in Queensland, either at large or as resulting from rearing the adult from fruit fly maggots, or as having been captured by any one of the fruit fly lures used, even kerosene. And this we note as a remarkable fact, seeing how often, as above stated, fruit of New South Wales (oranges) has in the past arrived here harbouring *Ceratitis capitata* maggots, and fruit trees to serve as hosts are growing in the near vicinity of the port. A *Diseases in Plants Act* was, however, included in Queensland's statutes in 1896, under which a commencement was made to deal with any such imported maggot-infested fruit in a summary manner. Moreover, the excellent figure of *Ceratitis capitata* that illustrates more than one publication by W. W. Froggatt on fruit flies so well portrays the insect that it has been adopted by not only the New South Wales Entomologist himself repeatedly, but by others elsewhere, and notably by F. Silvestri in his work referred to. And this being so, and much accessible literature relating to this fruit fly being available, it is not necessary to burden the text with descripive details. They key to our fruit fiy species (p. 180) and figure (Plate XXII.) should suffice for the identification of *C. capitata,* W.W., even in their absence.

Host Plants.—These are exceedingly numerous as well as varied, and include almost all the economic plants mentioned under this heading (Host Plants)—in treating of *Chætodacus Tryoni*, Frogg. (pp. 184-185).

Silvestri, indeed (*op. cit.*, pp. 45-47), gives a list of fifty-two plants whose fruit *C. capitata* will attack. And W. B. Gurney, dealing with New South Wales only, mentions oranges, mandarins, cumquots, seville oranges, persimmons, peaches, apricots, nectarines, guavas, and occasionally other cultivated fruits, including passion fruit, and exceptionally Maclura and Opuntia as possible hosts. No record has been seen of the so-called Mediterranean Fruit Fly having been met with infesting any native Australian fruits.

Habitat.—F. Silvestri, after full personal inquiry, states as follows: —"The natural habitat of *Ceratitis capitata* is certainly tropical Africa, south of 8 degrees north latitude" (Silvestri, 1914, p. 45). Wiedemann's type locality for the species—the East Indies—assigned to it in 1924 is, in fact, certainly an error, since the insect has never been reported as occurring there during the 100 years since he wrote. Its range of distribution is, however, now world-wide, including not only North, West, South, and South-east Africa, Madeira, and the Azores, but also the Mediterranean region (Spain, Italy, Malta, in addition to Algeria), the West Indies (Bermuda), Eastern South America, Hawaiian Islands, and lastly Australia.

Note.—A résumé covering these facts, accompanied by interesting personal observations, is given by W. W. Froggatt in his "Report on Parasitic and Injurious Insects" (1907-8, Syd., 1909, Part III. "Fruit Flies," pp. 100-105.

Occurrence in Australia.—This fruit fly, whose habitat has already gained a world-wide extension beyond its original home, arrived in Australia many years since, but when it first reached there and by what agency are not matters than can be now ascertained. The first recorded instance of its occurrence in Australia was in October-November, 1896, when it was found "infesting limes and afterwards apricots, peaches, nectarines, and figs" at Guildford, near Perth, Western Australia (C. Fuller). The insect found there was later identified by H. Tryon as *Ceratitis capitata*, Wied. (Halterophora). (C. Fuller and H. Tryon, Journ. Bureau Agr., W.A., 1897.)

Then early in 1898 it was reported as being present in New South Wales, peaches received in Victoria from Sydney being found to be infested by it (C. French). This discovery was at once confirmed by W. W. Froggatt, when maggots, in New South Wales peaches also, "supposed to be infested with the Queensland fruit fly," proved to be those exclusively of this insect (Froggatt, W. W., "Notes on Fruit Flies," Ag. Gaz., N.S.W., x. 6, p. 9, 1899). He further writes with reference to the fruit season 1898-9:—"All the specimens bred in this office from fruit from anywhere south of Newcastle have been the Mediterranean fruit fly, *Halterophora capitata*, Weid." . . . "Fruit containing maggots have come from all quarters around Sydney." (Froggatt, W. W., Rep., 1898-9, 1909, p. 98.)

This extended occurrence in New South Wales was not suggestive of a very recent introduction then. Nearly ten years later, in 1906 or 1907, we find that *Ceratitis* is established in certain parts of Victoria, in the Doncaster district especially; but whereas in both New South Wales and Western Australia the insect became wider disseminated following its discovery, in Victoria, on the other hand, when two seasons had elapsed since the outbreak there of the Mediterranean Fruit Fly, entire absence of the pest was reported (G. Quinn, Journ. Agr. of S. A., 1909, p. 90). However, early in 1924, a new instance of its occurrence in Victoria was revealed, the incident being that of the "Mildura Manifestation."

RIOXA, Walker.

RIOXA MUSÆ, Froggatt-Bezzi.

*ISLAND FRUIT FLY, SPOTTED FRUIT FLY, BOATMAN.

Froggatt, W. W., Agr. Gaz., N.S.W., 1889, and Reprint Misc. Pub. Dept. Agr., N.S.W., No. 303, 1889, *Trypeta musæ.*

Froggatt, W. W., Rep. Parasitic and Injurious Insects, 1907-8, Pt. III., pp. 113-114, pl. vii, *ib.*

Tryon, H., Reports *passim,* "Spotted Fruit Fly."

Tryon, H., Annual Report of Entomologists, 1904-5, p. 71 (*Tephritis psidii*), Gurney, Agr. Gaz., N.S.W., 1912 (*Dacus musæ* (Frog., Gurney).

Male and Female Measurements.—Length, body and ovipositor 6 mm., of wing 5 mm., ovipositor proper scarcely exserted, its sheath (abdominal joint 7) 1 mm.

Head.—Yellow, acquiring a brownish hue on drying (white in life); occiput without markings, ocellar spot simple; frons almost parallel-sided, face with usual *Rioxa* characteristics, antennæ with joints one and two subequal, three not greatly exceeding them; first joint with minute black spinelets terminally, second with a patch of same on inner surface and as short-black bristle in outer side of fine border, arista with a row of hairs on both upper and lower surfaces; palps pedunculate pyriform white with several black terminal hairs; proboscis white with yellowish hairs, cephalic bristles complete including p. vt. 2, oc. 2, orb. 2, 2, and ocp. well developed about 15, gular bristle present and with row of spinelets following orbital margin in both sides.

Mesonotum.—Uniformly pale-yellow, pleura and sterna lighter, whitish, with minute brownish appressed discrete pubescence, mesopleuron hairy in front, the thoracic chætotaxy complete, including

* W. B. Gurney (Agr. Gaz. N.S.W., XXI. 5, p. 428, 1910) throws doubt on its extra-Australian occurrence (implied in this designation), writing as follows:—"Island Fruit Fly (*Trypeta musæ*) ranges from Bulli, N.S.W., northwards to Queensland, described by W. W. Froggatt from specimens said to be from New Hebrides; hence the name; but it is possible (? probable) the locality of origin was Queensland."

amongst other bristles h., pr.s., dc. 2, a.sa. 1, m.pl. 2, s. subequal short, scut. 3.3—the intermediate of the three scutellar pairs much weaker than the others; pectus between legs of both second and third pairs clothed with short brown bristles; post-scutellum yellowish nitid.

Abdomen.—Above almost black with basal portion white and venter also white; segment 1 white with pubescence of minute black hairs at sides, 2 white, 3 white with fuscous lateral patch, 4 fuscous except narrow lunate white fore-border, 5 fuscous, 6 fuscous nitid, 7 (ovipositor sheath) elongate triangular with a narrow mesial ridge fuscous tipped with white, segments 2 and 5 partly, and 3 and 4 wholly, clothed with small black appressed pubescence, segment 7 with denser and finer pellory, segments 2 to 6 with the hind border ciliated with black bristles and similar ones occurring on their sides; beneath, abdominal mesial sclerites 2 to 4 oblong pale-fuliginous, 5 to 6 yellowish, latter apparently minutely shagrened, all minutely pubesent; the anterior 3 also each with a short black bristle.

Wings.—Pattern arrangement with hyaline colourless—or faintly whitish—portion almost predominating as in *R. Dunlopi,* and disposed as follows:—Costal cell entirely without band defining small cross vein, the stigma being black, a single triangular indentation beyond costal cells with its apex just exceeding 2nd longitudinal vein, two discal circular spots—one near end of 1st basal cell, and one in 1st posterior cell; 2nd posterior cell, too, almost wholly hyaline—except for extension from 1st posterior and band defining hind cross-vein, and uninterrupted hyaline along margin from 5th to base, the colourless area extending into and almost occupying discoidal and 3rd posterior cells, and entire base of wing excluding the foregoing colourless portions of the wing fuscous; venation:—1st longitudinal short ending about level with small cross-vein, costal bristle at end of auxiliary present, posterior cross-vein not bristly, and anal cell with inferior angle short broad and pointed—little-developed, thus.

Legs.—Unspotted; front coxæ with 4 black bristles on front side towards end, intermediate coxæ and coxæ of third pair, with 3 outer and 2 posterior ones; femora of 1st pair with long row of black bristles above and row at sides, and short linear series below, intermediate femora with short black hairs beneath, 3rd femora with 4 black bristles at end.

Note.—In a variety of this fruit fly, from the fruit of *Villaresia Moorei,* F. v. M. (Olacineæ) the following features are present:—In male, on femora of 1st pair legs occur 3 rows of erect long black hairs, two on the outer and one on the inner surfaces, the femora of the 3rd pair have again 2 rows of non-erect black bristles in the under surface. In the female the front femoræ are similarly endowed, and in the 3rd pair the decumbent black bristles towards the end of joint are longer than the others. In both sexes all the tibiæ exhibit a pilosity of minute decumbent black hairs and the tibiæ of the front pair are otherwise bare, but the tibiæ of the 2nd pair in both sexes have the stout terminal black bristle, and in the male a short erect black bristle on inter surface at two-thirds of its length; the tibiæ of the 3rd pair of legs have rows of black bristles in the male one of about 9, and in the female on the outer surface one of about 12 and a shorter one of 3.

Plesiotypes.—Reg. No. Q.M. D. 3137; two examples.

Host.—We have reared *Rioxa musæ* (Frogg.) from fruits of the following indigenous trees:—Meliaceæ, *Owenia venosa,* F. v. M. ("Crow's Apple"); Sapotaceæ, *Sideroxylon laurifolium,* F. v. M., *Sideroxylon myrsinoides,* A. Cunn; and Gurney, New South Wales, reports having reared it from the "Black Apple," *S. australe.*

A number of cultivated fruits are also subject to infestation by its maggots:—Citrus fruits—especially mandarins, apples, quinces, pears, &c.—also ripe bananas.

Note.—It would appear that its usual habit is to attack fruit already quite mature, or even in process of decay, or such as has acquired some skin blemish or injury; accordingly its presence is not regarded as fraught with serious significance. W. B. Gurney, Government Entomologist, N.S.W., has arrived at the same conclusion also. It is one of the flies attracted by bodies containing metheugenol, *e.g.,* citronella oil and Huon Pine oil.

Hab.—Probably throughout coastal Queensland, since we have established its occurrence in places situate from Rockhampton southwards to the border, and as far west as Stanthorpe. In New South Wales it occurs at spots along the coast to as far as Thirroul, situated to the south of Sydney (W.W.F.). In Froggatt's original account (1909, pp. 113-114) this fly *Rioxa musæ* is not only termed the "Island Fruit Fly" and to have come from the New Hebrides, but we are informed that, "Within the last few years this species has been introduced into Queensland." (Both statements are open to question. H.T.)

Note.—This fruit fly has long been recognised as frequenting fruit trees of one kind or another, being often quite prevalent in citrus orchards, and popularly has been referred to as the "Boatman," in allusion to its habit of slowly moving its wings paddle-fashion, and again as the "Spotted Fruit Fly." However, it was not described until 1899 when W. W. Froggatt named it *Trypeta musæ* n.sp. from specimens reared from maggot-infested bananas said to emanate from New Hebrides. In assigning it then to *Trypeta* he was persuaded, at the time, that the fly belonged to the same genus as the well known Apple Maggot Fly—*Trypeta pomonella* of U.S.A. (*vid.* Agr. Gaz. N.S. Wales, 1899, p. 501, Pl. II., figs 1 and 2). Again in 1910 he treated of it under the name—the "Island Fruit Fly"—*Trypeta musæ* (Report 1907-8, p. 113-114, Pl. VII., figs. 1, 2, and 3*a*).

Further, under *Trypeta musæ,* he in 1910 gave an account of it (*vid.* Proc. Lin. Soc., N.S.W., XXXV., Py. 4, p. 372, 1910). However, since Froggatt in his earlier paper described figures 1 and 2, on the plate that illustrated the insert, "*Tephritis psidii,* Froggatt," this name was applied to *Rioxa musæ* in H. Tryon's Annual Reports of Entomologist, Depart. Agr. Qd.," for both 1904-5 and 1906-7, Gurney in a paper on "The Island Fruit Fly, *Dacus musæ*," 1912, gave an interesting account of the life history of the species, and he, moreover, not only altered its generic designation from *Trypeta* to *Dacus*, but threw doubt on the type individual ever having originated in the New Hebrides, stating, "Possible locality of origin is Queensland."

RIOXA ARAUCARIÆ, sp. nov.

(Plate XXIV., Fig. 12.)

ARAUCARIA SPOTTED FRUIT FLY (*Tryon*).

Male and Female. Measurements:—

Male.—Length 7 mm., length of wing, 6·5 mm. *Female.*—Length of body 7·5 mm., wing 5 mm.

Head.—Pale brownish-yellow; occiput brownish-orange above hoary whitish lower sides and beneath, a row of five minute black bristles from foramen on each side towards outer of vertical bristles; vertex coloured as frons, no markings; frons brownish-yellow, a small patch of blackish pilosity in centre below, a dark infuscation below eye and lower front-orbital bristle, as broad as long scarcely narrowing anteriorly, upper half flat, lower half lowly convex; lunule back; face and epistome dark-brown, non-concave, flat with a mesial longitudinal ridge, antennal furrows reaching epistome, a wide darkish-hued groove continuous with antennal one along lower border of eye to occiput, separate from latter by a narrow whitish line; epistome distinct from mouth-border, concolourous with face; palpi, light coloured, proboscis dark, both bristly, former fringed with hairs; antenna, 2 basal joints whitish about equal in length, joint 2 swollen at end covered with small short black setæ, joint 3 very short about equal 1 and 2, lower border evenly convex end rounded arista with 2 rows of black hairs (plumose on its 2 sides); cephalic bristles as follows:—Chætotaxy complete as in typical Rioxa spp. (p.vt., vt., oc., or., ocp.); orbitals 2 upper anterior one longer, 2 lower anterior very small, these included in a row of nine additional short weak spinelets, oc.p. a row of 8, a row of minute bristles along mouth border following lower orbital border, or which hinder longer; all bristles and spinelets black.

Mesonotum.—Conspicuously white and black longitudinally striped, sparsely clothed with short dark pubescence; in detail—a dark mesial stripe, narrowed and linear in front of suture, widening behind from fore to hind border and continued narrowing to a point to apex of scutellum; a noto-pleural band from hinder supra-alar bristle contiguous to upper side of humeral callus, but not reaching anterior border; a mesopleural band contiguous to lower side of this callus, extending also hindwards beneath wing below infra-alar seta to mesophragma; a broad dark fuscous band on side of pleuro-sternum united with its fellow in front; interspaces whitish; scutellum broadly triangular above with usual

3 pairs of bristles of which the middle (lateral) pair are shorter than others, surface broadly whitish on each side, this colour passing to its under-surface; mesophragma black, whitish in front nitid—sloping backwards; thoracic bristles—chætotaxy complete, including in addition to those of the Dacine fruit flies h., pr. st., dc., all black and long, the anterior supra-alar and presutural especially so; a row of bristles crossing pectus behind, and meso-sterna in front of mid pair of legs.

Abdomen.—Above black nitid, *white banded* with short black pubescence and a continuous lateral band of black hairs and long terminal black bristles on last segment; first, second, third, and fourth segments with each a transverse white band wide in centre and narrowed laterally—along hind border under surface with a well-defined reddish patch at base.

Note.—In a male individual a white spot in the centre of fifth segment above is noted, and bristly hind borders of segments; sixth segment above glossy, hairy, venter white at base.

Wing.—Elongated, first longitudinal vein meeting costal border much nearer end of auxiliary than of second longitudinal; well before small cross vein; second longitudinal straight (not wavy); third curved towards hind border; small cross vein beyond middle of discoidal cell; second basal cell elongated, nearly four times greatest breadth, narrowing internally; anal cell with inferior angle drawing to a point much longer than anterior angle and much longer than second basal; a costal bristle present; general colour of wing brown fuscus, stigma wholly of darker hue; the hyaline patches and markings as follows:—One triangular incisure immediately beyond stigma with apex attaining third longitudinal, costal cell except on outer side of cross vein: a round spot filling first basal towards outer end: two bars in first posterior cell—one crossing it beyond the middle, and one large oblique one beyond it reaching wing margin in front of fifth longitudinal vein; a band crossing discoidal cell, parallel to hind cross vein: a broad triangular patch from wing margin to second posterior extending to fourth and fifth posterior cells respectively; central area of second basal and of anal cells and third and fourth posterior cells wholly white also.

Legs.—With minute black pubescence, front ones stoutest; coxæ almost black; femora wholly infuscated; tibiæ short arcuate, brownish horn-coloured; femora with densely-planted long black setæ, especially on under surface where they form a brush; middle and hind legs, including coxæ pale-brownish horn colour, seta at end of middle tibia and short setæ at the end of each tarsal joint, black.

Types.—Reg. No. Q.M. D. 3138; Holo- Allo- and 1 Paratype.

Loc.—Macpherson Range, South Queensland (Tryon).

Host.—Not known, all the individuals, including both sexes, observed captured on being attracted by fresh resin of *Araucaria Cunninghamii* (Coniferæ) H.T.

Note.—The colour-pattern of thorax, and that of abdomen, *inter alia*, distinguish it from the known species of Queensland Rioxæ, including those herein described.

RIOXA JARVISI sp. nov. (Pl. XXIV., Fig. 13).

JARVIS SPOTTED FRUIT FLY.

Female Measurements.—Head with thorax 5 mm. (abdomen in specimen bent under), wing 8 mm. long.

Head.—Yellowish, with only small ocellar spot black, occiput uniformly coloured; frons rather shorter than twice width, slightly convexly widened in middle, longitudinally tumid; face with the central area prominently raised along middle, and deeply excavate anteriorly by oral cavity, antennal grooves extending well beyond antennæ, cheeks narrow gules wide especially beneath eyes; antennæ joints one and two subequal short tumid, joint three short about equal one and two, not reaching front border fuscous, arista black basally brown shortly pectinate on both sides; cephalic chætotaxy as follows:—Vt. three pairs —two short behind ocelli, one on each side of these two, but rather anterior—shorter still, and one on each side—level with former of last—longer, ocp. about 7, s.or. 2, i.o.r. (dropped out) at least once, oc. 2 small, gular bristle present, and a row of about six unequal ones on gular margin of mouth cavity, all these bristles black; also numerous very short black hairs on frons.

Mesonotum.—Brownish-yellow above and below without markings, above with a greyish coating, and numerous black appressed hairs, these occurring more sparsely beneath, scutellum tumid nitid black at sides, with a central area narrowing from front border backwards yellow; mesophragma black nitid; thoracic chætotaxy as follows:—hm. n.pl. 2, m.pl. 1 (also 3 shorter), a.sa. 1, p.sa. 2, i.a. 1, st. 1, prsc. 2, all these bristles black; scutellar bristles three pairs, the terminal and intermediate (lateral) ones subequal; a row of about six very short erect pale hairs in front of scutellum.

Abdomen.—Ovate broad black with whitish transverse bands and having minute blackish pubescence with the hairs at the sides of segments 3 and 4 longer, but the hind-margins of segments 2, 3, and 4 glabrous; the whitish bands—narrowly pale-brown anteriorly—broadly bounding segments 1, 2, and 3 behind.

In a second example the undersurface with first and second segments alone whitish.

Wings.—Dark fuscous black hyaline at base, with clear or white pattern as follows:—A triangular spot forming a single indenture beyond the first longitudinal vein with apex extending to third longitudinal one, an oblong spot crossing first posterior cell (that may be continuous with one in second posterior cell), a row of spots at outward end of first basal cell and also a bar—of two spots merged—at base of latter, a large broad triangular blotch in the second posterior cell arising broadly from the wing margin, and—whilst contiguous to the fourth longitudinal vein—reaching inner anterior angle, two discoidal spots, the external portion of discoidal cell, one circular near outer angle, one continued through fifth longitudinal vein, coalescing with the third posterior cell's white portion; hyaline basal portion of wing with the following parts black—the end of the subcostal cell and a band including humeral cross-vein, and a spot in second basal cell; the sub-costal cell, except outwardly, auxiliary cell, and almost entire third posterior cell, except extension from fifth longitudinal vein, thus white, stigma, and costal bristle, if present, black.

Legs.—First pair much shorter and also stouter than either second or third ones, all yellow with very short fine fulvous pubescence, denser on tarsi; femora of one with numerous conspicuous black bristles on outer face, with a series of four longer ones (bristles) of same colour towards end on lower border of this; middle femora with a band of short black hairs on outer face below, and with three black bristles towards end on inner side; the tibiæ of this pair with four longer and four shorter black bristles on border and the usual two long black bristles at end. Hind legs with scattered short black bristles, the tibiæ slightly swollen beyond base, and with a few weak dark bristles along upper border.

Type.—Reg. No. Q.M. D. 3139; holotype (female).

Loc.—Stanthorpe (H. Jarvis) and Warwick (H.T.) *host plant* unknown. In both localities captured at large; in the latter met with beneath an apricot tree in fruit.

Described from a single specimen captured at Stanthorpe in 1896 by H. Jarvis, local Entomologist, Department of Agriculture, Queensland.

Note.—The figure, Pl. xxiv., fig. 13, is that of a specimen (locality Stanthorpe, and of similar history) manifesting varietal features. This not available when compiling foregoing description.

OTHER QUEENSLAND RIOXA SPECIES.

The writer has received examples of still three other species of Queensland members of the genus Rioxa since this paper was written.

OTHER AUSTRALIAN SPECIES OR RIOXA.

(1) *Rioxa bicolor*, Macquart, *Urophora bicolor*, Macquart, Mem. Soc. Lille 144 (124) 17, pl. 7, fig. 7, 1885. *Trypeta bicolor* (Macq.) Froggatt, W.W., Austr. Ins. 1908, p. 308; *ib.*, Report 1907-8, p. 114. *Rioxa bicolor* (Macq.) Bezzi, Bull. Ent. Res. (x) (1919), pp. 4-5.

Host.—Undertermined. *Loc.*—(*a*) Adelaide (type locality); (*b*) New South Wales, Bathurst district, collected on the wing (W. W. Froggatt).

Note.—Froggatt remarks in describing *Roxia muscæ* Frog. and in comparing *R. bicolor* Macq. with it, that the former is "a much lighter coloured fly, with the wings more lightly clouded."

(2) *Rioxa termitoxena,* Bezzi (1919), Bull. Entom. Res. (x) (1919), pp. 1-5, plate xxiii., fig. 11.

Note.—Bezzi (*l.c.*) states that this differs from *R. muscæ* (Frogg.), *inter alia,* in having on the mesonotum in front of the scutellum two black spots.

Host.—Occurs in the termitaria of white ants (Hill).

Hab.—Northern Territory.

This insect of such remarkable associations—as indicated above—is referred to here as well as illustrated to promote success in search for it in Queensland, and so lead to the further elucidation of its remarkable habits brought to light by Hill.

H.T., 1st July, 1926.

DESCRIPTION OF PLATES.*

PLATE XX.

Fig. 1.—*Chætodacus tryoni*, Froggatt (Tephritis). Male.

Fig. 2.—*Chætodacus tryoni*, Froggatt (Tephritis). Female.

Fig. 3.—*Chætodacus dorsalis*, Hendel. Male.

PLATE XXI.

Fig. 4.—*Chætodacus Bryoniæ*, Tryon. Male.

Fig. 5.—*Chætodacus cucumis*, French. Female.

Fig. 6.—*Chætodacus Jarvisi*, Tryon. Female.

PLATE XXII.

Fig. 7.—*Chætodacus musæ*, Tryon. Female.

Fig. 8.—*Ceratitis capitata*, Wied. (Trypeta). Female.

PLATE XXIII.

Fig. 9.—*Bactrocera caudatus*, Fabr. Female.

Fig. 10.—*Rioxa musæ*, Froggatt. Female.

Fig. 11.—*Rioxa termitoxena*, Bezzi. Male.

PLATE XXIV.

Fig. 12.—*Rioxa araucariæ*, Tryon. Female.

Fig. 13.—*Rioxa Jarvisi*, Tryon. Female.

Fig. 14.—*Chætodacus niger*, Tryon. Male.

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* Figures all magnified representations.

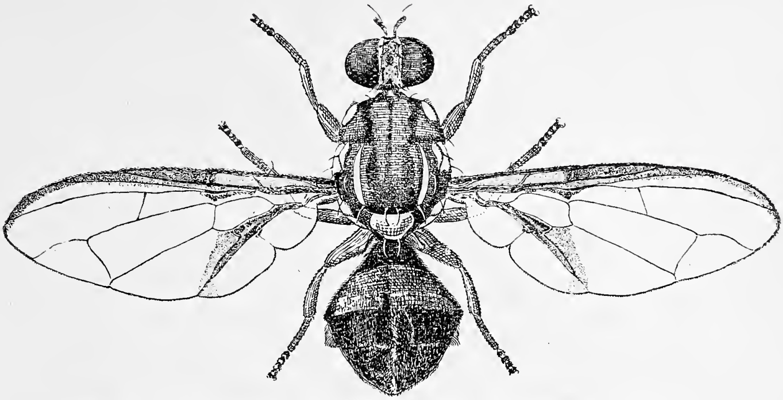


Fig. 1.—*Chætodaçus tryoni,* Froggatt (Tephritis). Male.

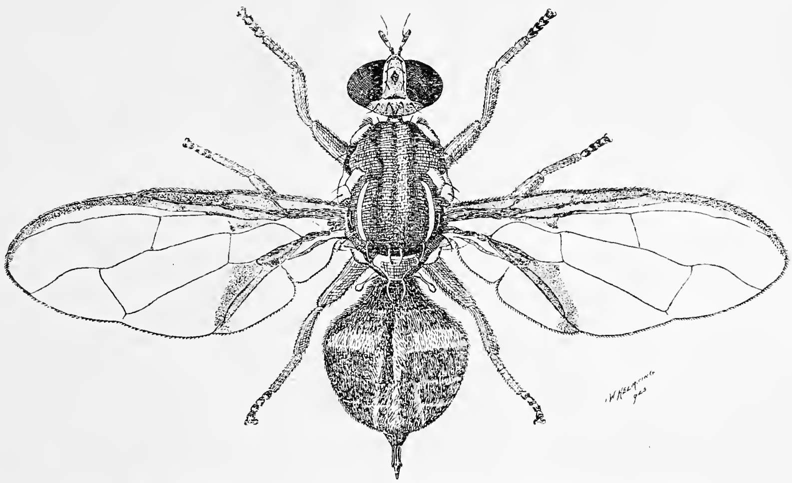


Fig. 2.—*Chætodacus tryoni,* Froggatt (Tephritis). Female.

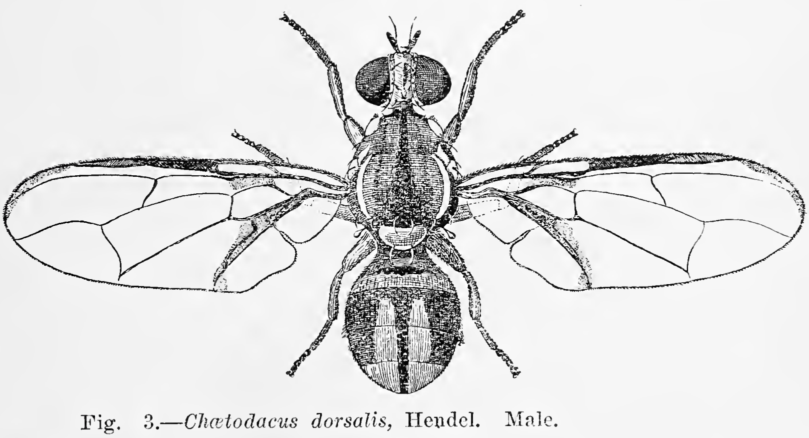


Fig. 3.—*Chætodacus dorsalis,* Hendel. Male.

[*Face page* 224.]

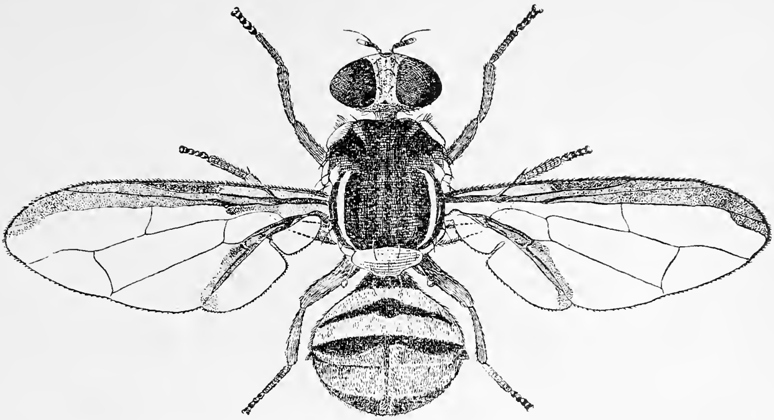


Fig. 4.—*Chætodacus Bryoniæ*, Tryon. Male.

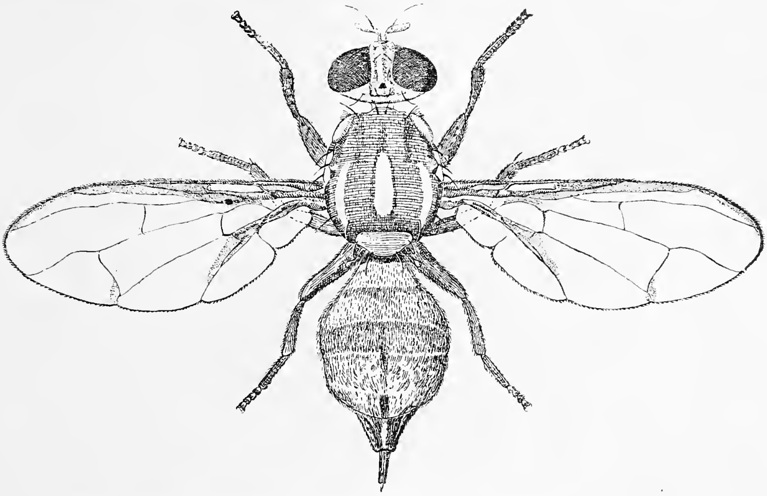


Fig. 5.—*Chœtodacus cucumis*, French. Female.

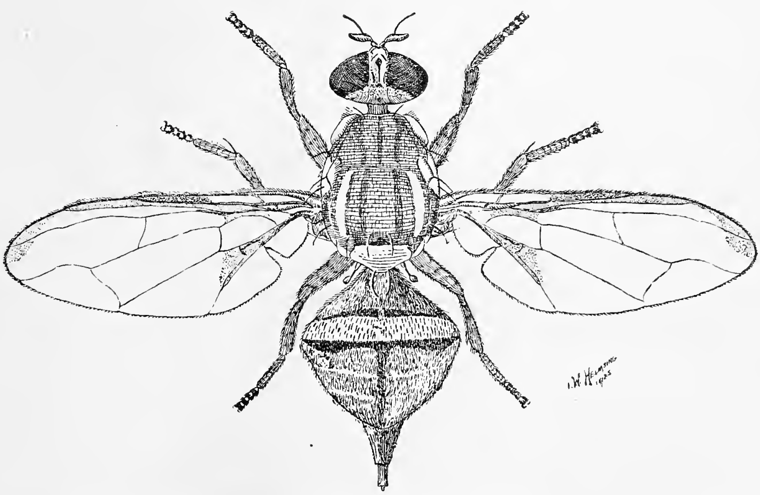


Fig. 6.—*Chætodacus Jarvisi*, Tryon. Female.

[*Face page* 224.]

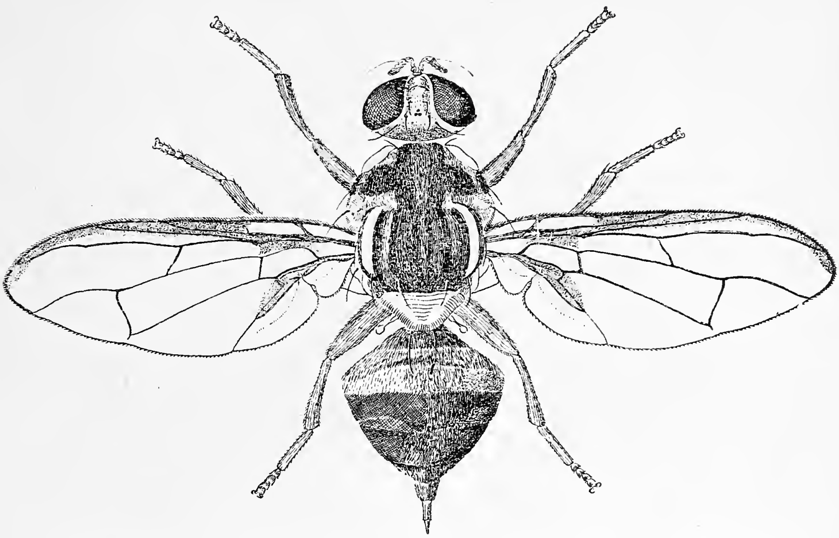


Fig. 7.—*Chætodacus musæ*, Tryon. Female.

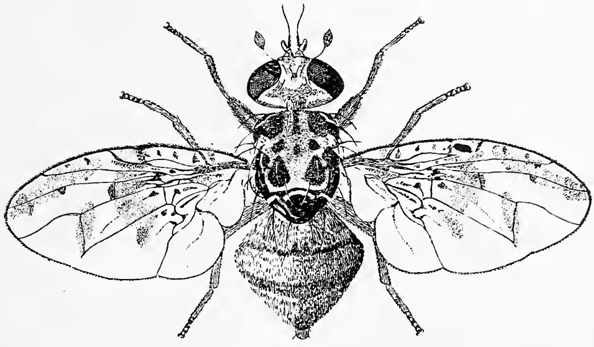


Fig. 8.—*Ceratitis capitata*, Wied. (Trypeta). Female.

[*Face page* 224.]

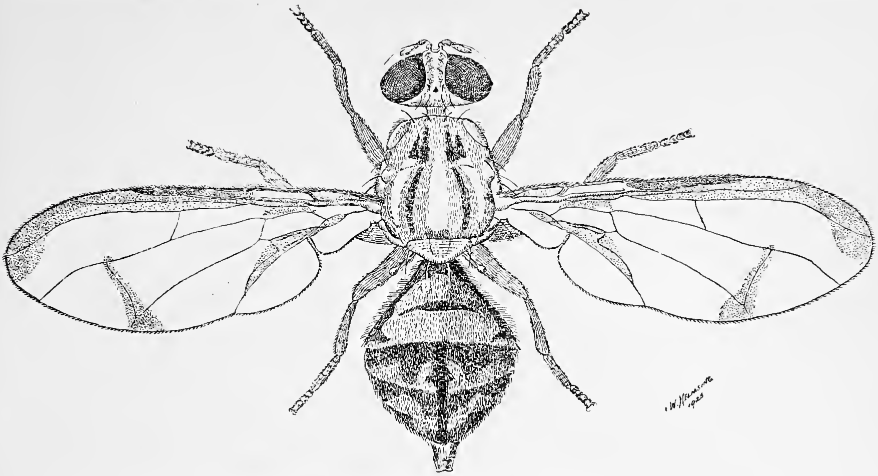


Fig. 9.—*Bactrocera caudatus,* Fabr. Female.

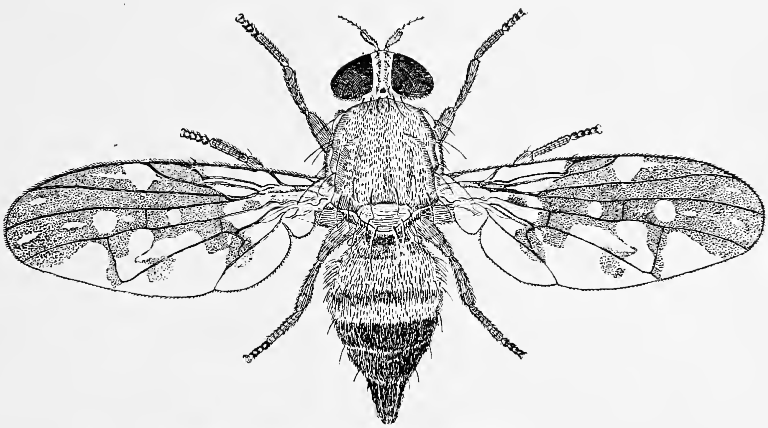


Fig. 10.—*Rioxa musæ,* Froggatt. Female.

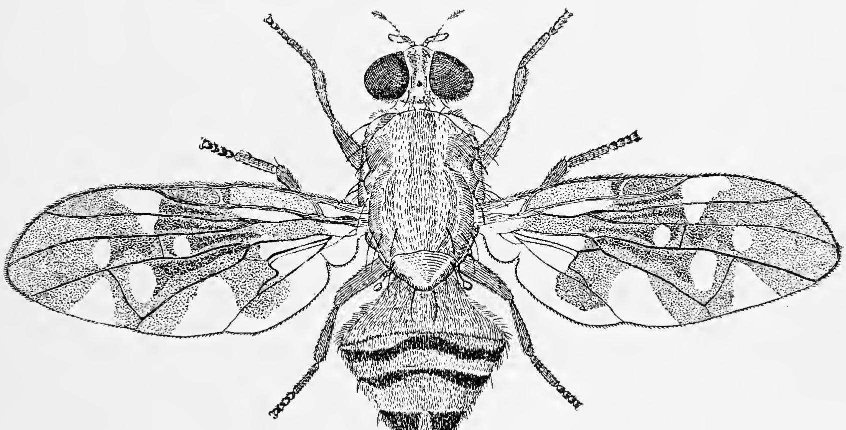


Fig. 11.—*Rioxa termitoxena,* Bezzi. Male.

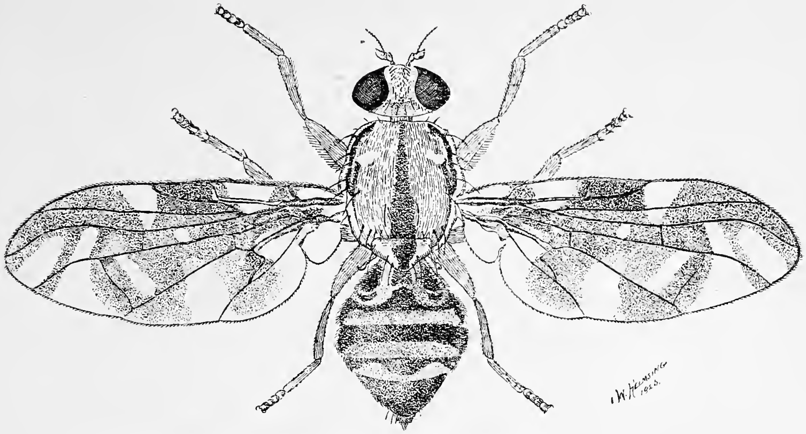


Fig. 12.—*Rioxa araucariæ*, Tryon. Female.

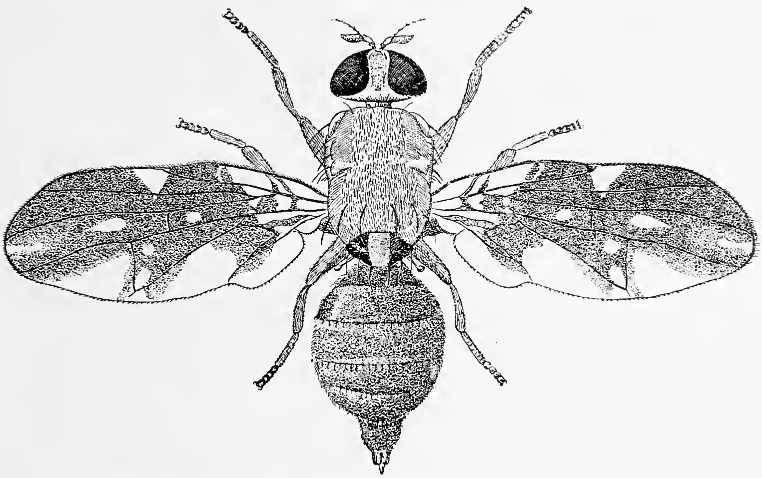


Fig. 13.—*Rioxa Jarvisi*, Tryon. Female.

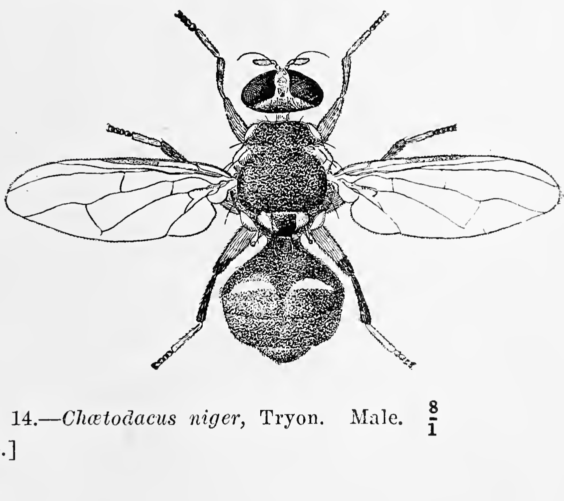


Fig. 14.—*Chætodacus niger*, Tryon. Male. $\frac{8}{1}$

[*Face page* 224.]

Plants Collected in Papua by C. E. Lane-Poole.

By C. T. White, Government Botanist, and W. D. Francis, Assistant Government Botanist, Brisbane.

(Text-figures 1–19.)

(Read before the Royal Society of Queensland, 25th October, 1926.)

Mr. C. E. Lane-Poole was commissioned by the Commonwealth Government to report on the forest resources of Papua. For this purpose he visited Papua, and in 1922 and 1923 made collections of plant specimens, principally of the trees. His material was forwarded to us for identification. The specimens were well preserved, and were accompanied by extensive notes on the appearance of the living plants, their economic properties, and the characteristics of the wood of the arboreal species. These notes were incorporated in his published report, "The Forest Resources of the Territories of Papua and New Guinea," Commonwealth Government publication, Melbourne, 1925. Dr. E. D. Merrill, when visiting Australia to attend the Pan-Pacific Science Congress in 1923, kindly looked through the material and made notes on some of the species which were of considerable value in identifying them. Some of the material was sent to different workers for report, and their help has been acknowledged in the text referring to the particular specimens submitted. After investigating the Forests of Papua Mr. Lane-Poole undertook a forest survey of the Mandated Territory of New Guinea. The botanical material collected in this territory has been partly investigated by the authors, who hope to publish the results of their determinations in these Proceedings next year.

Mr. Lane-Poole's collection is particularly interesting, as he made special efforts to obtain specimens of the larger forest trees, plants often neglected by the general collector.

The collections emphasise close relationship with the flora of South-eastern Asia rather than with Australia. A particularly interesting record from the point of view of plant geography is that of a new species of *Achradotypus* (Sapotaceæ), a genus only previously known from New Caledonia.

Family POLYPODIACEÆ.

Dryopteris gongylodes O. Ktze. Embi Lake, 225, sterile fronds, August, 1922.

Family TAXACEÆ.

Podocarpus amara Bl. Mt. Obree, spur leading from Laruni to summit, 377, specimens bearing young male amenta, February, 1923.

Podocarpus neriifolius Don. Foothills of Hydrographers Range, 238, immature flowering specimens, August, 1922; Baroi River, 50 miles down from where the Purari splits into its three main rivers, 275, specimen bearing a few young fruit, October, 1922.

Podocarpus cupressina R. Br. Owen Stanley Range, 5,000 feet, on trail between Kokoda and the Gap, 269, foliage specimens, August, 1922.

Dacrydium elatum Wall. Divide between Adai and Naro Rivers, 4,000 feet, 404, foliage specimens, February, 1923.

Dacrydium falciforme Pilger. Top of ridge between Adai and Tuhui Rivers, East Central Division, 397, foliage specimens only, February, 1923. These specimens were sent to the Royal Botanic Gardens, Kew, for the purpose of comparison. Major K. W. Braid reported as follows:—"The Papuan specimen is probably correctly named. Although the leaves are very variable in size, there are no other specimens at Kew with quite such small leaves. From specimens bearing only leaves it is difficult to make any decision, and the differences of shape and size may arouse suspicion and suggest that the plant may be new."

Phyllocladus hypophyllus Hook. f. Mt. Obree and Main Owen Stanley Range, 359A, foliage specimens, February, 1923.

Family PINACEÆ.

Araucaria Cunninghamii Ait. Laruni, 5,000 feet (near Mt. Obree), 376, barren branchlets, February, 1923.

Libocedrus papuana F. v. M. Owen Stanley Range, 8,000–10,000 feet, 381, foliage specimens, February, 1923.

Family GNETACEÆ.

Gnetum Gnemon Linn. Veimauri Creek, 80, fruiting specimens, May, 1922; forests of the foothills of the Hydrographers Range, 242, flowering specimens, August, 1922.

Family PANDANACEÆ.

Freycinetia angustissima Ridl. Ridge between Adai and Naro Rivers, East Central Division, 410, fruiting specimens, February, 1923.

Family PALMÆ.

Arenga gracilicaulis F. M. Bailey. Baroi River, 313, fruiting specimens, November, 1922.

Family ARACEÆ.

Epipremnum Zippelianum Engl. Between Nornu and Naro Rivers, 4,000 feet, East Central Division, 401, flowering specimens, February, 1923.

Pistia stratiotes Linn. Embi Lake, Hydrographers Range, 256, August, 1922.

Family FLAGELLARIACEÆ.

Susum anthelminticum Bl. Banks of Embi Lake, Hydrographers Range, 253, flowering specimens (female), August, 1922.

Family CASUARINACEÆ.

Casuarina nodiflora G. Forst. Between Menari and Efogi at an altitude of 4,000–5,000 feet, Central Division, 426, fruiting specimens, February, 1923.

Family FAGACEÆ.

Quercus spicata Smith. Between Menari and Efogi, 5,000 feet, Central Division, 425, immature flowering specimens, February, 1923.

Quercus spicata Smith var. depressa King. Kargi, 5,000 feet on the western side of the Owen Stanley Range, 270, foliage specimens, and old acorns, August, 1922.

Quercus Junghuhnii Miq. Forests between Pernambata and Embi in the Hydrographers Range, 219, fruiting specimens, August, 1922; between Uberai and Sogeri, 427, flowering specimens, February, 1923.

Quercus pseudo-molucca Bl. Vanapa, about 12 miles above the village of Dora, 1,000–2,000 feet, 117, fruiting specimens, June, 1922.

Quercus lamponga Miq. Menari, Central Division, 418, specimens bearing male and female flowers, February, 1923.

Family ULMACEÆ.

Celtis philippinensis Blanco. Veimauri Creek, 47, flowering specimens, June, 1922.

Family MORACEÆ.

Antiaris toxicaria Lesch. Baroi River, Purari Delta, 305, immature flowering specimens, October, 1922.

Dammaropsis Kingiana Warb. Forests between Kokoda, 1,200 feet, and gap in Owen Stanley Range, 7,000 feet, 260, fruiting specimens, August, 1922. The leaf in these specimens is inserted on a petiole 6 cm. long.

Family URTICACEÆ.

Elatostemma macrophyllum Brongn. var. majusculum H. Winkl. Road from Kokoda to Port Moresby, 4,000 to 5,000 feet on Owen Stanley Range, 259, flowering specimens, August, 1922.

Elatostemma velutinicaule H. Winkl. On trail from Kokoda to the Gap at 5,400 feet, 267, flowering specimens, August, 1922.

Pipturus incanus Wedd. Forests around village of Wasida and along the main path to Wire Rope, 168, flowering specimens, July, 1922.

Pipturus argenteus Wedd. Old farm lands, Menari, 5,000 feet, Central Division, 422, flowering specimens, February, 1923.

Family PROTEACEÆ.

Grevillea densiflora C. T. White. Menari, 4,000 feet, Central Division, 420, flowering specimens, February, 1923.

Family POLYGONACEÆ.

Muehlenbeckia platyclados Meissn. Laruni, Owen Stanley Range, 5,000 feet, 363, flowering specimens, February, 1923.

Family NYCTAGINACEÆ.

Pisonia Brunoniana Endl. Aroa, Central Division, 128, flowering specimens, June, 1922.

Family NYMPHÆACEÆ.

Nymphæa gigantea Hook. Embi Lake, Hydrographers Range, 250, flowering specimens, August, 1922.

Family RANUNCULACEÆ.

Clematis Pickeringii A. Gr. Forests around village of Wasida and along the main path to Wire Rope, 179, flowering and fruiting specimens.

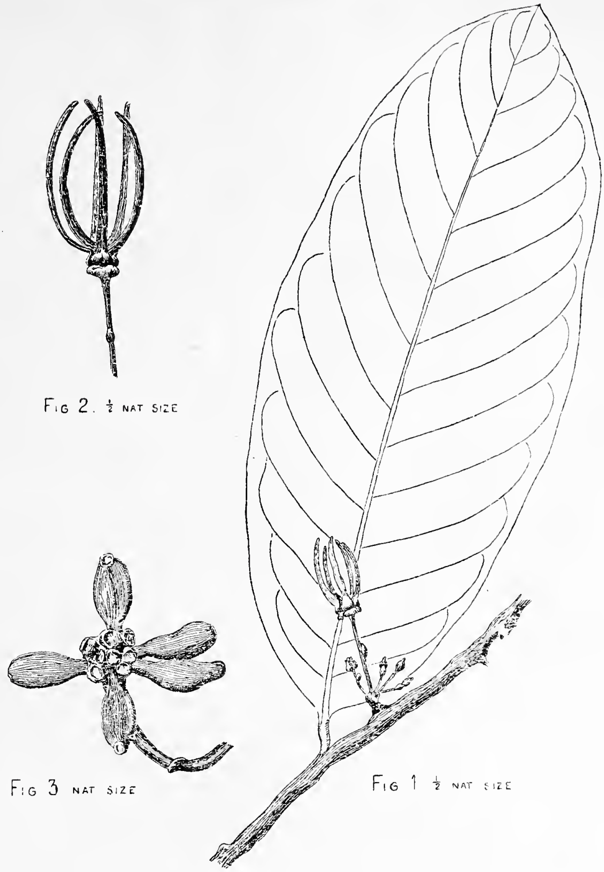
Family MAGNOLIACEÆ.

Drimys cyclopum Diels. Mist forests, Mt. Obree, 8,000 feet, 347, flowering specimens, January, 1923.

Family ANONACEÆ.

Cyathocalyx polycarpum sp. nov. (Text-figure 1).

Arbor parva, 14 m. in altitudine, 45 cm. in circuitu (Lane-Poole); partibus junioribus et ramulis et foliis subtus et inflorescentiis plus vel minus dense stellato-pubescentibus. Ramuli teretes 3 mm. diam. infra apicem 14 cm. Folia alterna petiolata, petiolis pubescentibus ca. 1 cm. longis; laminis 13–20 cm. longis 2–2½ plo longioribus quam latæ ellipticis, ad basin rotundatis vel rare sub-cuneatis, ad apicem breviter acuminatis, marginibus recurvis, supra nitidis glabris costa media et nervis exceptis subtus stellato-pubescentibus, nervis lateralibus in utroque latere 11–14 in utraque pagina visibilibus sed subtus multo prominentioribus et elevatis. Inflorescentiæ laterales ca. 1·5–2·5 cm. supra foliorum axillares sitis; pedunculo communi brevissimo vel obsoleto bracteis brevis latis ornato; pedicellis 2–4, 1·2–2·5 cm. longis circiter medium bractea concava late ovata ornatis. Calyx alte 3–lobatus, lobis ad apicem recurvis, cum 2 mm. longo recurvo acumine 5 mm. longis, ad basin ca. 4 mm. latis. Petala exteriora 4 cm. longa ad basin concava et 5 mm. lata, in parte superiore 3 mm. lata, ad apicem obtusa; petala interiora similia sed breviora (3·5 cm. longa). Stamina pæne obconica in sectione transversa quadrangulares 1·5 cm. longa cum 1 mm. longo obliquo connectivo. Carpella ca. 20, glabra (in statu immaturo modo a nobis visa).



Text-Figure 1.—*Cyathocalyx polycarpum* sp. nov. 1, flower-bearing twig; 2, flower; 3, immature carpels.

Forests between Perembati and Embi in the Hydrographers Range. No. 225. Small tree with stem 18 inches in girth and 45 feet overall; bark mottled grey and brown; smooth; flowers have a slightly spicy smell. Occurs throughout the rain forests of the Northern Division 1,500 feet, flowers from July to August.

Allied to *C. petiolatus* Diels Engl. Jahrb. 49 Band 1 Heft. 127, from which it differs in its larger leaves with more lateral nerves and in its much wider petals.

Family MYRISTICACEÆ.

Horsfieldia sylvestris Warb. Veimauri Creek, 22, bearing male flowers; Buna, 231, bearing immature female flowers.

Myristica pseudo-argentea Warb. (?). Sageri, Northern Division, 206, fruiting specimens, July, 1922. Leaves rounded at base, slightly acuminate at apex, glaucous on underside, principal lateral nerves 17–19 on each side of midrib, blade 47 cm. long, 16 cm. broad, petioles 2–3 cm. long, the margins involute above. Fruit 6 cm. long, 4·3 cm. diameter, seed 3·7 × 2 cm., fruiting pedicel 8 mm. long.

Family LAURACEÆ.

Cinnamomum Massoia Schewe. Veimauri Creek, 57, leaves only.

Litsea grandifolia Teschn. Veimauri Creek, 60, flowering specimens, May, 1922. The specimens differ from those described by Teschner (Engler's Bot. Jahrb. 58, 397) in the leaves being scarcely cuneate at the base and in some cases the apices being protracted into an acute point. In our specimens there are six flowers in the involucres in some cases.

Family HERNANDIACEÆ.

Hernandia peltata Meissn. Buna, 234, flowering specimens, August, 1922.

Family ROSACEÆ.

Rubus rosæfolius Sm. Laruni Village, spur of Mt. Obree, 5,000 feet, 345, flowering specimens, February, 1923.

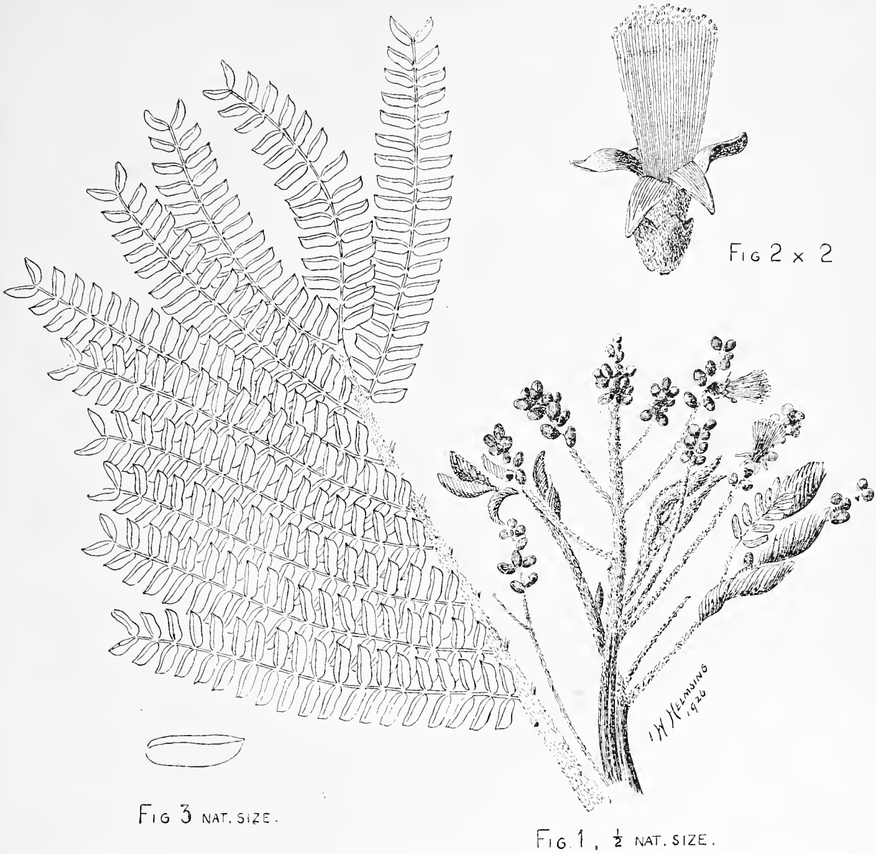
Rubus moluccanus Linn. Forests around village of Wasida and along main path to Wire Rope, 177, flowering and fruiting specimens, July, 1922.

Family LEGUMINOSÆ.

Archidendron chrysocarpum Lauterb. et K. Sch. Between Nornu and Naro Rivers, East Central Division, 399, flowering specimens, February, 1923. When better known these specimens may be found to represent a new species. They differ from the description of *A. chryso carpum* (Fl. deutsch. Schutz. Sudsee, 344, 1901) in having broader leaflets, pedicels 2–3 times as long and petals pubescent on the outside.

Albizzia fulva sp. nov. (Text-figure 2).

Arbor magna, 45 m. in altitudine, 390 cm. in circuitu (C. E. Lane-Poole), partibus junioribus pilis ferrugineis dense et molliter vestitis, ramulis angularibus. Folia breviter petiolata, rhachide cum petiolo brevi 8–15 cm. longa dense ferrugineo-pubescenti inter pinnas supremas duas glandulis crassiusculis suborbicularibus obsita; pinnis 8–11 jugis oppositis vel inferne alternis; foliolis 10–20 jugis brevissime petiolulatis supra tenuiter subtus dense pubescentibus 3–4 mm. latis 2–3 plo longioribus oblique oblongis perinæquilateris costa media margini antico proxima. Inflorescentia spicata spicis paniculas axillares ca. 10 cm. longas dispositis. Flores albi sessiles; calyce puberulo cupulari, tubo ca. 2 mm. longo, lobis 5 vel 6 inæqualibus deltoideis ca. 1 mm. longis; corolla campanulata extus pubescenti intus glabra, tubo 3–4 mm. longo, lobis 5 vel 6 lanceolatis acutis ca. 4 mm. longis. Tubus stamineus glaber 4–5 mm. longus, filamentis liberis numerosis 11–12 mm. longis; antheris dorsifixis latioribus quam longæ ca. 0·3 mm. latis. Ovarium glabrum breviter stipitatum, stylo tenuo. Legumen nobis non visum (Fruit: a thin pod, 5 inches long and ½ inch wide.—C. E. Lane-Poole, Forest Resources Pap. & N.G. 91. 1926).



Text-Figure 2.—*Albizzia fulva* sp. nov. 1, flower-bearing twig; 2, flower; 3, leaflet.

3,000–5,000 feet on the Owen Stanley Range. Trail from Kokoda to the Gap, 263, a very large tree with stem of 13 feet girth and 150 feet high with an 80-ft. bole.

Among previously described species most closely allied to *A. falcata* (Linn.) Baker (*A. moluccana* Miq.), from which it differs in its dense ferruginous indumentum and the absence of a gland near the base of the petiole. The plant has somewhat the general facies of a *Serianthes,* but from the description of the pod given by the collector evidently belongs to *Albizzia.* It agrees in some respects with *Serianthes Ledermannii* Harms., the pod of which is also unknown, but differs from that plant in its markedly excentric midrib of the leaflets and the absence of a gland on the petiole.

Adenanthera pavonina Linn. Forests around village of Wasida and along main path to Wire Rope, 174, flowering specimens, July, 1922; Baroi River, Purari Delta, 316, flowering specimens, November, 1922.

Cassia glauca Lamk. Spur of Mt. Obree, 6,000 feet, 351, flowering and fruiting specimens, January, 1923.

Cassia Bartonii F. M. Bailey. Valley of the Asover, 4,000 feet, Upper Kemp Welch River, 344, flowering specimens, February, 1923.

Stylosanthes mucronata Willd. Port Moresby, 441, foliage specimens, April, 1923.

Desmodium sinuatum Blume. Spurs of Mt. Obree, 5,000 feet, 352, flowering specimens, January, 1923.

Desmodium umbellatum D.C. Port Moresby, 436, flowering specimens.

Pongamia glabra Vent. Close to sea-coast near Buna, 216, flowering specimens, July, 1922.

Strongylodon lucidus Seem. Junction of Adai and Inumu Rivers, 2,200 feet, East Central Division, 402, flowering specimens, February, 1923.

Family OXALIDACEÆ.

Oxalis corniculata Linn. Lower spurs of Mt. Obree, 5,000 feet, 350, flowering specimens, January, 1923.

Family RUTACEÆ.

Evodia accedens Bl. Old farm lands at 5,000 feet, Owen Stanley Range, 364, flowering specimens, February, 1923.

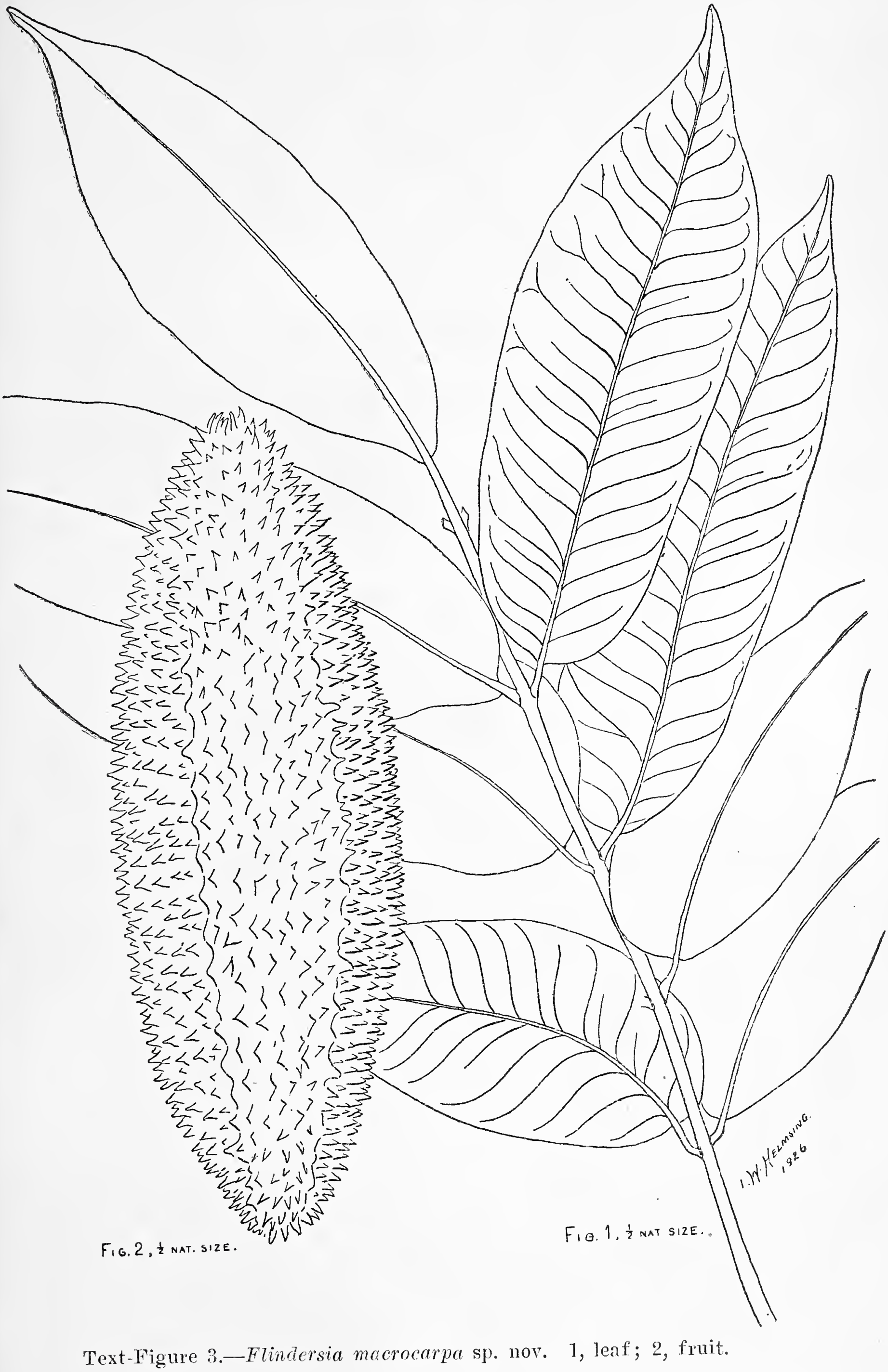
Evodia hortensis Forst. Baroi River, Purari Delta, 307, flowering and fruiting specimens, November, 1922.

Evodia lamprocarpa K. Sch. Forests around village of Wasida, and along main path to Wire Rope, 169A, fruiting specimens, July, 1922.

Flindersia Pimenteliana F. v. M. Mt. Obree to Laruni Spur, 7,000 feet, 382, foliage and empty capsules, February, 1923. This is a common species of North Queensland.

Flindersia macrocarpa sp. nov. (Text-figure 3).

Arbor magna 30 m. alta. Folia alterna imparipinnata 4–5 jugata, petiolata, rhachide cum petiolo 28–33 cm. longa, internodiis inter foliola ca. 4 cm. longis, petiolo ipso ca. 11 cm. longo; foliolis plerumque oppositis petiolulatis petiolulis 6–8 mm. longis, laminis 12–20 cm. longis ca. 3–plo longioribus quam latæ oblongo-lanceolatis sæpe falcatis apice acuminatis vel subacuminatis basi obliquis præcipue in foliolis inferioribus, nervis lateralibus utroque latere 16–22, costa media et nervis lateralibus et in pagina superiore et inferiore visibilibus, venulis vix visibilibus. Flores nobis non visi. Capsula 20 cm. longa—usque ad 25 cm. (Lane-Poole)—6–7 cm. diam. valvis dorso 2·5 cm. latis, rigidis puberulis tuberculis dense armatis, tuberculis 1 cm. altis et ad basin 5 cm. diam. e basi usque ad apicem sensim attenuatis, placentis 2·5 cm. altis dorso 1·3 cm. latis, seminibus ala cinctis cum ala 8 cm. longa 2–2·5 cm. lata, seminibus ipsis elliptico-oblongis 4 cm. longis 2·7 cm. latis.



Text-Figure 3.—*Flindersia macrocarpa* sp. nov. 1, leaf; 2, fruit.

5,000 feet up the main Owen Stanley Range, No. 362. Large tree with stem of 8 feet in girth with a 70-ft. bole and 100 feet overall. Native name "Zizanu" (Laruni).

Capsule valves collected by C. T. White and described in Proceed. Linn. Soc. N.S.W. 46, 329 (1921) under doubtful species as *Flindersia papuana* F. v. M. belong to this species. The capsule valves collected by White were also recorded in Proc. Roy. Soc. Queensland 34, 38 as *F. papuana* F. v. M. As it is now evident that more than one species of *Flindersia* are represented in Papua, it is very doubtful to which one the immature fruit described by F. v. Mueller under *F. papuana* refers. It is, therefore, not possible to establish definitely the species to which Mueller's fruit belongs.

This species is distinguished from the previously described ones by its very long capsule.

Family BURSERACEÆ.

Canarium grandistipulatum Lauterb. Vailala River, 338, fruiting specimens, January, 1923.

Canarium lineistipula Lauterb. et K. Sch. Forests of the Lower Kumusi, near Oitatandi village, 197, flowering specimens, July, 1922; Baroi River, Purari Delta, 306, flowering specimens, October, 1922.

Canarium maluense Lauterb. Foothills of the Hydrographers Range, 244, flowering specimens, August, 1922.

Family MELIACEÆ.

Xylocarpus Granatum Koen. Within 100 yards of the beach near Buna, 218, flowering specimens, July, 1922; Galley Reach among mangroves, 343, fruiting specimens, January, 1923.

Dysoxylum Pettigrewianum F. M. Bailey. Baroi River, Purari Delta, 300, immature flowering specimens, October, 1922.

Dysoxylum fissum sp. nov. (Text figure 4).

Arbor 27 m. in altitudine, 183 cm. in circuitu (Lane-Poole), partibus junioribus non visis. Folia alterna (Lane-Poole), 6 jugis, impari-pinnata petiolata, petiolo cum rhachide 65 cm. petiolo ipso 16 cm. longo, et rhachide et petiolo velutino-pubescenti supra applanato subtus rotundato basin versus marginibus acute angulato; foliolis oppositis vel infimis paribus alternis; foliolorum lateralium petiolulis 1–1·5 cm. longis, folioli terminalis petiolulo 10 cm. longo; laminis 8–9 cm. latis ca. 2½ plo longioribus supra omnino glabris, subtus nervis exceptis glabris anguste ovatis acuminatis basi infoliolis superioribus cuneatis in inferioribus rotundatis; nervis lateralibus utrinque 10–12 et in pagina inferiori et superiori visibilibus sed in pag. inf. multo prominentioribus, venulis haud distinctis. Flores racemosi, racemis 10–20 cm. longis in axillis foliorum fasciculatis; pedicellis 4–5 mm. longis, calyce tubulato extus ferrugineo-pubescenti, tubo 5 mm. longo, lobis 3 deltoideis vel late ovatis 1–2 mm.

Text-Figure 4.—*Dysoxylum fissum* sp. nov. 1, lower part of leaf; 2, raceme with young fruit; 3, calyx laid open; 4, ovary and style; 5, immature fruit.

longis; petalis 4, extus in parte superiori dense pubescenti tubo stamineo liberis, tubo stamineo glabro 1 cm. longo 8-lobulato, lobis bifidis; antheris 8 inter lobulos sub sinubus affixis oblongis 1 mm. longis disco tubulato 2·5 mm. longo ovarium ambienti; ovario 4-loculari dense ferrugineo-pubescenti, stylo supra glabro infra pubescenti, stigma discoideo fere 1 mm. diam.

Baroi River, No. 282. Flowering in October. A tree of medium size, with stem 6 feet in girth, 60 feet bole, and 90 feet overall; narrow buttresses up to 9 feet.

Aglaia obliqua sp. nov. (Text-figure 5).

Text-Figure 5.—*Aglaia obliqua* sp. nov. 1, leaf; 2, part of panicle; 3, calyx and ovary.

Arbor partibus junioribus et petiolis et inflorescentiarum ramulis squamis stellatis ochraceis vestitis. Folia petiolata rhachide cum petiolo 18–20 cm; petiolo ipso 4–7 cm; foliolis 8–11 alternis vel rarius oppositis petiolulatis petiolulis 3–4 cm. laminis 2·5–3 cm. latis 2–4 plo longioribus ovatis vel oblongis sæpe leviter falcatis ad apicem obtuse sed prominenter acuminatis, ad basin perobliquis nervis lateralibus utrinque 12–15 costa media et nervis lateralibus et in pagina superiore et inferiore visibilibus venulis in pagina inferiore solum visibilibus. Paniculæ axillares ambitu pyramidales foliis longiores. Flores sessiles vel breviter pedicellati, calyce extus squamis stellatis vestito, tubo cupulari 1 mm. longa, lobis 5 obtusis multo latioribus quam longi calycis tubo multo brevioribus; petalis 5 glabris ovatis obtusis fere 2 mm. longis; tubo stamineo glabro ovoideo vel urceolato 1·2 mm. longo, antheris 5 lanceolatis 0·8 mm. longis sessilibus intus tubi basin versus insertis; ovario globoso, glabro.

Camp 8 miles west of Buna, Northern Division, on the Ambogi River, No. 132.

This species belongs to the section Euaglaia, and is characterised by the insertion of the anthers inside near the base of the urceolate staminal tube.

Aglaia sapindina Harms. Forests around village of Wasida and along main path to Wire Rope, 162, flowering specimens, July, 1922.

Family MALPHIGIACEÆ.

Ryssopterys timorensis Bl. Menari, 5,000 feet, Central Division, 421, flowering specimens, February, 1922.

Family EUPHORBIACEÆ.

Breynia cernua Muell. Arg. Forests around village of Wasida and along main path to Wire Rope, 166, fruit-bearing specimens, July, 1922.

Baccaurea papuana F. M. Bailey. Forests between Pernambata and Embi in the Hydrographers Range, 230, flowering specimens, August, 1922.

Daphniphyllum glaucescens Bl. Mt. Obree, Laruni Spur, 9,000 feet, 378, specimens bearing immature male flowers, February, 1923.

Macaranga riparia Engl. Forests around village of Wasida and along main path to Wire Rope, 164, flowering specimens, July, 1922. Mr. Lane-Poole remarks that the species is found on old farm lands everywhere.

Aleurites moluccana Willd. Aroa, Central Division, 126, foliage specimens.

Endospermum formicarum Becc. Veimauri Creek, 21, bearing young fruit, June, 1922.

Family ANACARDIACEÆ.

Mangifera minor Bl. Forests around village of Wasida and along main path to Wire Rope, 170, flowering specimens, July, 1922.

Pleiogynium Solandri Engl. Aroa, 125, flowering and fruiting in May and June, 1922.

Spondias dulcis Forst.f. Baroi River, Purari Delta, 301, foliage specimens only, October, 1922; Vailala River, 328, fruiting specimens, December, 1922.

Semecarpus australiensis Engl. Vanapa River, about 6 miles above the village of Dora, 93, leaf-bearing specimens only.

Family SAPINDACEÆ.

Pometia pinnata Forst. Banks of the Veimauri Creek, Central Division, 5, flowering specimens.

Alectryon repando-dentatus Radlk. Port Moresby, 438, fruiting specimens, April, 1922.

Dodonea viscosa Linn. Grass lands and old farm lands near Menari, 5,000 feet, Central Division, 419, fruiting specimens, February, 1923.

Ganophyllum falcatum Bl. Baroi River, Purari Delta, 281, 310, foliage specimens, October, 1922.

Family RHAMNACEÆ.

Alphitonia moluccana Teijsm. and Binn. Forests around village of Wasida and along main path to Wire Rope, 169, fruiting specimens, July, 1922.

Family ELÆOCARPACEÆ.

Elæocarpus megacarpus Schltr. Valley of the Mimai, head waters of Kemp Welch River, 4,000 feet, 355, specimens bearing immature fruit, January, 1923.

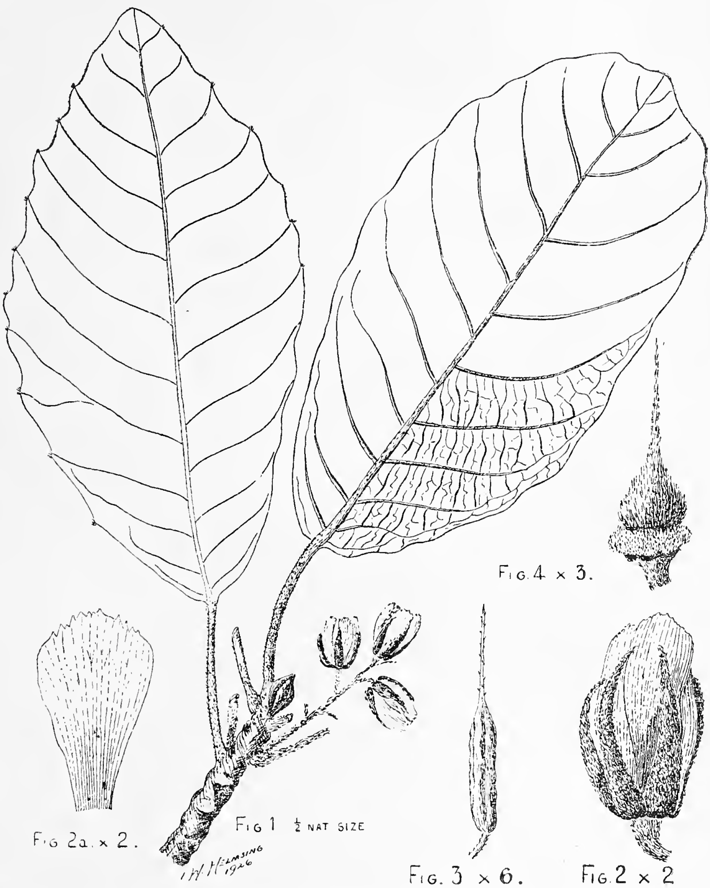
Elæocarpus comatus sp. nov. (Text-figure 6).

Arbor magna 240 cm. in circuitu (Lane-Poole) ramulis et petiolis et inflorescentiis dense ferrugineo pubescentibus. Ramuli teretes 6 mm. diam. infra apicem 6 cm. Folia ad apices ramulorum conferta, petiolata, petiolis 5–7 cm. longis; laminis 15–19 cm. longis 1½–2 plo longioribus quam latæ, obovatis et ad apicem et ad basin ipsam rotundatis, marginibus sinuatis, pilorum fasciculis minutis nervos laterales præcipuos terminantibus supra glabris costa media et nervis lateralibus dense ferrugineo-pubescentibus exceptis; subtus costa media et nervis lateralibus dense ferrugineo-pubescentibus ceteram tenuiter pubescentibus, nervis lateralibus in utroque latere 11, costa media et nervis et venulis reticulatis et in pagina superiore et inferiore visibilibus sed subtus multo promentioribus et elevatis. Racemi axillares 3–5 cm. longi; pedicellis 1·5 cm. longis. Sepala 8–10 mm. longa lineares extus dense pubescentes intus glabra. Petala 1–1·1 cm. longa extus vinculo media leviter pubescenti ceteram glabra ad apicem dentata dentibus triangularibus acutis ca. 1 mm. longis. Stamina numerosa ca. 8 mm. longa, filamentis hirsutis 1–2 mm. longis, antheris pubescentibus linearibus 3 mm. longis, seta terminali pubescenti 2–3 mm. longa. Ovarium obtuse 4-angulatum, dense ferrugineo-pubescente, 2–4 loculare; stylo apicem versus glabro, 5–6 mm. longo.

Kumusi River, Northern Division, No. 185. Large tree with stem 8 feet in girth and 55 feet bole; buttressed to a height of 5 feet. Flowers in July. Native name "Ohe."

Named *E. comatus* in allusion to the tufts of hairs terminating some of the nerves on the margin of leaves. Allied to *E. amplifolius* Schltr., from which it is distinguished by its smaller leaves and flowers, the latter less than half the size of the flowers of *E. amplifolius*.

Elæocarpus sepikanus Schltr. Forests around village of Wasida and along main path to Wire Rope, 178, flowering specimens, July, 1922. The ovary is 3-celled in these specimens.



Text-Figure 6.—*Elæocarpus comatus* sp. nov. 1, flower-bearing twig; 2, flower; 2*a*, petal; 3, anther; 4, ovary and disk.

Elæocarpus novo-guineensis Warb. Buna on the Ambogi River, 141, fruiting specimens. The racemes are only 3·5–5 cm. long in our specimens.

Antholoma Tieghemi F. v. M. Owen Stanley Range, 6,000 feet, 370, flowering specimens. The specimens differ from F. v. Mueller's description (Journal of Botany 31, 322, 1893) in having slender peduncles 2·5–3 cm. long. The stamens are 8–9 mm. long, including the long point of the anthers.

Family TILIACEÆ.

Columbia æquilateralis sp. nov. (Text-figure 7).

Arbor mediocris (Lane-Poole), ramulis pilis et stellatis et simplicibus dense obtectis. Folia alterna, petiolata, petiolis 6–8 mm. longis, laminis 4–5 cm. latis, 2–3 plo longioribus oblongo-ovatis ad basin rotundatis vel subcordatis ad apicem acuminatis, marginibus serratis supra tenuiter

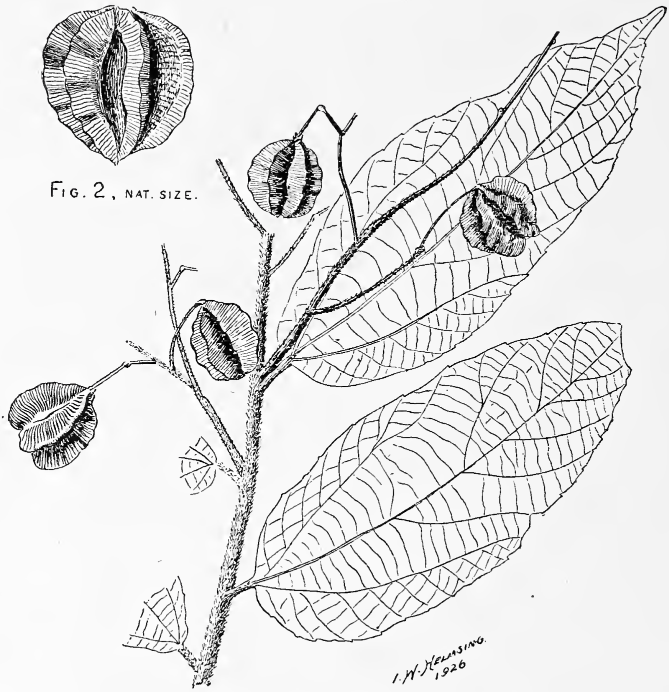


Fig 1. ½ nat. size

Text-Figure 7.—*Columbia æquilateris* sp. nov. 1, fruit-bearing twig; 2, fruit.

subtus densissime pilis stellatis vestitis; costa media et nervis lateralibus et venulis transversis utrinque visibilibus sed in pagina inferiore prominentioribus. Paniculæ terminales et ex axillis superioribus orientes. Flores ignoti. Fructus pedicellatus (pedicello 8–9 mm. longo) alis 3 vel 4 instructus obovatus cum alis usque ad 2 cm. longus et 1·8 cm. latus.

Aroa No. 132. A medium-sized tree with a light grey bark.

Specimens of the above plant were forwarded to the Director of the Botanic Gardens, Buitenzorg, Java (Dr. W. Docters van Leeuwen), and he answered: "The Chief of the Herbarium replies that the material collected in Papua by Mr. Lane-Poole has been compared with the specimens in the Buitenzorg Herbarium in which collections of specimens from New Guinea are lacking. From the literature at hand *C. celebica* seems to be a very near ally to this species, which the late Dr. Koorders identified with C. *serratifolia* by comparison at Kew Herbarium. Still there are some differences—viz., the leaves are nearly equal-sided at the base, whereas in all the specimens from the Celebes and the Philippines the leaf bases are very oblique, and the fruits are greater and truncate at the top."

Family MALVACEÆ.

Urena lobata Linn. Old farm lands on lower spurs of Mt. Obree, 5,000 feet, 349, flowering and fruiting specimens, January, 1923.

Hibiscus tiliaceus Linn. Coast near Buna, 208, flowering specimens, July, 1922.

Affinities *Hibiscus D'Albertisii,* F. v. M. Veimauri Creek, 28, flowering specimens, June, 1922. May prove to be arboreal form of *H. D'Albertisii*, from which species it differs chiefly in the mostly non-cordate leaves, the non-cordate bracts of the involucre, and the less prominent venation of the leaves.

Thespesia populnea Corr. Along sea beach near Buna, 214, flowering specimens, July, 1922.

Family STERCULIACEÆ.

Kleinhovia hospita Linn. Forests around village of Wasida and along main path to Wire Rope, 182, flowering specimens, July, 1922. Mr. Lane-Poole remarks that this species occurs very frequently in places where there has been a native garden, and that the young leaves are cooked as a vegetable.

Pterygota Forbesii F. v. M. Veimauri Creek, 24, flowering and fruiting specimens, June, 1922.

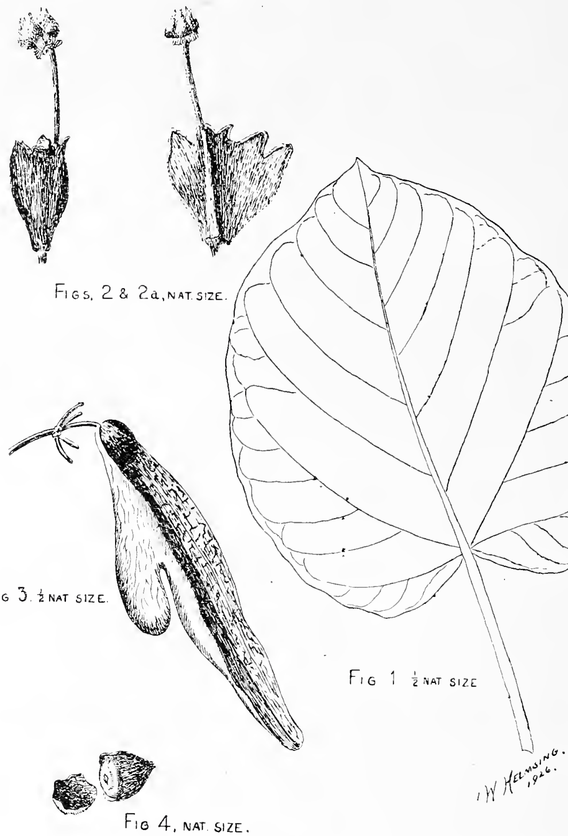
Pterocymbium stipitatum sp. nov. (Text-figure 8).

Arbor magna 37 m. alta, foliis ante anthesin deciduis (Lane-Poole), partibus junioribus pilis stellatis fuscis vestitis sed mox glabris ramulis teretibus. Folia petiolata, petiolis 4–6 cm. longis, laminis cordatis orbicularibus vel late ovatis 8–10 cm. latis apice breviter et obtuse acuminatis 5 nerviis, costa media et nervis et venulis utrinque visibilibus sed subtus prominentioribus. Paniculæ apicem versus ramulorum defoliatorum confertæ, ca. 8 cm. longæ, ramulis pilis stellatis paucis vestitis, pedicellis tenuis 2–4 mm. longis sub floribus articulatis. Calyx campanulatus extus glaber intus pubescens cum lobis 2–3 mm. longis, ovato-lanceolatis acutis 1·2–1·5 cm. longus, loborum marginibus ciliatis. Columna genitalis pubescens vel hirsuta pilis simplicibus, 2·5 cm. longis antheris 15 sessilibus omnibus ca. 1 cm. longis simplici serie dispositis. Ovarium 5–lobatum pubescens ca. 4 mm. diam., stylo 2 mm. longo. Folliculi membranacei valde nervosi 10 cm. longi, lobo superiore 1·7 cm. lato lobo inferiore apice rotundato ca. 2 cm. longo 1·5 cm. lato; semine ovoideo 7 mm. longo.

Allied to *P. javanicum* R. Br., from which it differs in its longer staminal column (which exceeds the calyx) and shorter calyx lobes.

Baroi River, Purari Delta, No. 279, flowering in October. A very large tree with stem 9 feet in girth, 100 feet bole, and 130 feet overall. Apparently deciduous (C. E. Lane-Poole).

Heritiera littoralis Ait. Vanapa River, about 6 miles above the village of Dora, 85, leaf-bearing specimens only; Vailala River, 333, flowering specimens, December, 1922.



Text-Figure 8.—*Pterocymbium stipitatum* sp. nov. 1, leaf; 2, flower; 2*a*, flower with calyx laid open, showing the column; 3, follicle; 4, seed.

FAMILY DILLENIACEÆ.

Wormia quercifolia sp. nov. (Text-figure 9).

Arbor magna insignis 30 m. alta, 365 cm. in circuitu (Lane-Poole), partibus novellis sericeo-pubescentibus. Ramuli teretes in juventute striati 4 mm. diam. infra apicem 10 cm. Folia petiolata; petiolis 4–5 cm. longis striatis in juventute alatis, alis 4 × 0·6 cm.; laminis 9–16 cm. longis $1\frac{1}{3}$–2 plo longioribus quam latæ, ovato-orbicularibus vel late ellipticis apice ipso acuminato vel subacuminato, marginibus prominenter undulato-sinuatis vel in foliis parvioribus crenatis, nervis lateralibus in utroque latere 7–8, costa media et nervis utrinque visibilibus sed subtus prominentioribus et valde elevatis, venis transversis numerosissimis in sicco utrinque prominulis. Racemi terminales (?) vel ex axillis supremis

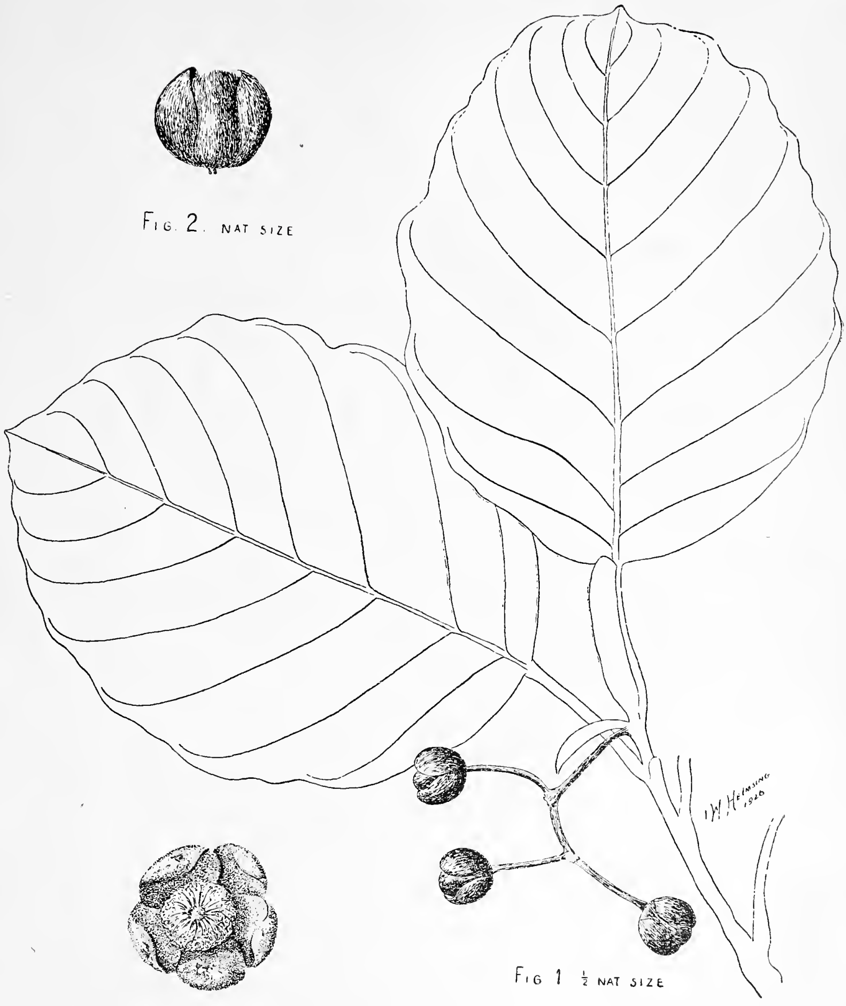


Fig. 3. ½ NAT. SIZE.

Text-Figure 9.—*Wormia quercifolia* sp. nov. 1, flower-bearing twig; 2, unopened flower; 3, flower with calyx opened, exposing the stamens.

orientes, ca. 4-flori, rhachide valde flexuosa 3–4 cm. longa; pedicellis 1·5–2·5 cm. longis. Flores glabri, sepalis 5, orbicularibus concavis carnosis, exterioribus 1·8 cm. diam. interioribus 1·4 cm. diam.; petalis (mox deciduis et in alabastris a nobis modo visis) sepalis similibus sed minoribus. Stamina numerosa 10–12 mm. longa. Carpella 7–10, stylo tenuo 7 mm. longo.

Forests between Pernambata and Embi in the Hydrographers Range. No. 226. A large handsome tree, 80 feet bole and 100 feet overall, with stem 12 feet in girth, spur rooted but not buttressed. Flowers July-August in the Northern Division.

Allied to *Dillenia macrophylla* Diels, from which it differs in its much smaller leaves.

Saurauja plurilocularis sp. nov. (Text-figure 10).

Arbor glabra parva (6 m. alta—Lane-Poole). Folia basin versus sensim attenuata et petioli per totam longitudinem decurrentes cum petiolis 34–48 cm. longis, 3–4 plo longioribus quam lata; petiolis ipsis ca. 4 cm. longis anguste alatis ad basin dilatis et subauriculatis; laminis oblanceolatis apicibus breviter acuminatis, marginibus in parte inferiore integris vel fere integris, in parte superiore distincte serrulatis; costa media ad basin ca. 5 cm. lata, nervis lateralibus tenuibus in utroque latere 35 vel pluribus utrinque visibilibus sed subtus prominentioribus, venulis subtus visibilibus. Inflorescentiæ cymosæ, cymis trichotomis trifloris; pedunculo 11–16 cm. longo; pedicellis 5–8 cm. longis. Flores albi (Lane-Poole); calycis lobis 5 ovatis vel orbicularibus obtusis 1·5–1·7 cm. longis; petalis 5, 2·5–3·5 cm. longis ca. 1·5 cm. latis per $\frac{1}{4}$–$\frac{1}{3}$ partem longitudinis eorum connatis; staminibus ca. 100 (in phalanges 5 petalis oppositas dispositis?), filamentis tenuis 2·5 mm. longis ad basin brevissime connatis, antheris oblongis 4 mm. longis inter loculos ad apicem emarginatis, loculis poro subterminale vel rima brevi dehiscentibus; ovario glabro 7–loculari, stylis 5 mm. longis per totam longitudinem eorum connatis.

Banks of the Upper Naro River between Mt. Obree and Kargi (Owen Stanley Range). No. 416. A small tree 20 feet high. It grows with its roots practically in the torrent and has for its neighbour *Dammarapsis Kingiana*. The flowers are white but the petals are a faint rose pink at the base.

The type material consists of two leaves and three cymes, all detached, and it is not certain whether these latter represent complete inflorescences or only parts of a larger, more complex one.

This species appears to be exceptional in the genus on account of its 7-celled ovary. In Gilg's description of the genus in the Naturlichen Pflanzenfamilien it is stated that the ovary is 5–3 celled. The species is also somewhat remarkable because of the absence of the scales and hairs which so frequently characterise species of the genus, although the very young shoots, when they become known may be found provided with the peculiar indumentum. Its long-pedunculate, cymose, triflorus inflorescence resembles that of *Saurauja pendula* Bl., but the new species is readily distinguished from *S. pendula* by its united styles, glabrous ovary and greater number of stamens.

Saurauja vallium sp. nov.

Frutex vel arbor parva usque ad 6 m. alta, partibus junioribus et pedicellis et calycis lobis extus squamis appressis obsitis; squamis brunneis vel stramineis lanceolatis acuminatis usque ad fere 0·5 mm. longis. Folio petiolata, petiolis 6–10 mm. longis; laminis 4·5–7 cm. longis $1\frac{1}{2}$–2–plo longioribus quam latæ obovatis vel late oblanceolatis margine serratis apice abrupte acuminatis basi late cuneatis vel leviter rotundatis, supra glabris subtus pallidioribus et glandulis stellatis tenuiter obsitis; nervis lateralibus in utroque latere 6–8 subtus

Text-Figure 10.—*Saurauja plurilocularis* sp. nov. 1, leaf; 2, trichotomous cyme, bearing an unopened flower; 3, flower with calyx opened and stamens removed, showing the ovary; 4, stamen.

prominulis venulis reticulatis visibilibus sed non distinctis. Flores axillares fasciculati fasculis 1–3 floris e tuberculis parvis squamosis orientibus, pedicellus tenuis valde inæqualis 3 mm.–2 cm. longis. Calyx alte lobatus, lobis 5 ovatis vel fere orbicularibus obtusis 6–8 mm. longis. Petala 5, glabra, 10–11 mm. longa. Stamina numerosa monadelpha, parte connata ca. 3 mm. longa parte libera ca. 2 mm. longa; antheris oblongis 2 mm. longis loculis ad apicem leviter divergentibus, poris terminalibus dehiscentibus; stylis connatis 3–4 mm. longis.

Forests of the ravines of the grassy hills around Iorobaiva 3,000–4,000 feet., between Mt. Obree and Kargi, Owen Stanley Range. No. 431. Shrub to small tree 20 feet overall, flowers pink, showy, flowering February, 1923.

This species is allied to *S. bifida* Warb., from which it differs in its much smaller leaves and smaller non-paniculate inflorescence.

Saurauja Poolei sp. nov. (Text-figure 11).

Text-Figure 11.—*Sarauja Poolei* sp. nov. 1, flower-bearing twig; 2, flower; 3, stamen; 4, flower with petals and stamens removed, showing the ovary and styles.

Arbor parva (usque ad 6 m. alta) habitu subdiffusa (Lane-Poole); partibus junioribus et ramulis et foliis et inflorescentiis setulis fulvis obtectis. Folia petiolata; petiolis 1·5–3 cm. longis; laminis 11–18 cm.

longis ca. 2-plo longioribus quam latæ supra parcius subtus pallidioribus et multo densius præcipue in nervis setis obtectis, obovatis, basi cuneatis, apice acuminatis, marginibus setiferis setis ca. 1 mm. longis et 2–4 mm. remotis, nervis lateralibus in utroque latere 11–13, costa media et nervis utrinque visibilibus sed subtus prominentioribus et elevatis, venulis subtus prominulis. Pedunculi ex axillis superioribus orientes, subumbellati, 2–3 flori, 3–4 cm. longi; pedicellis 1–2 cm. longis. Calyx extus setosus, intus glaber alte 5-lobatus, lobis 5 late ovatis 8–10 mm. longis et fere æque latis. Petala 5, glabra 1·2–1·5 cm. longa. Stamina glabra, numerosa; filamentis 1·5–2·5 mm. longis; antheris linearibus 1·7 mm. longis; loculis poris obliquis terminalibus dehiscentibus. Ovarium glabrum, globosum 5-loculare; stylis 5 glabris, 4 mm. longis.

Forests around village of Wasida, No. 165. Small tree up to 20 feet; spreading, almost rambling habit; undergrowth in rain forests. Found in all rain forests up to 2,000 feet. Flowers in July in the Buna district.

This species belong to Diels' section, Setosæ (Engl. Bot. Jahrb. lvii., 448) and is closely allied to *S. Schumanniana* Diels., from which it differs in its broader leaves (up to 9 cm. broad), petioles twice as long and larger flowers.

Family OCHNACEÆ.

Schuurmansia Henningsii K. Sch. Foothills of the Hydrographers range, 237, fruiting specimens, August, 1922; Owen Stanley Range, 6,000 feet, 371, flowering specimens, February, 1923.

Family GUTTIFERÆ.

Calophyllum inophyllum Linn. Coast near Buna, 209, flowering specimens, July, 1922.

Garcinia Hollrungii Lauterb. Vanapa River, about 12 miles above the village of Dora, 115, fruiting specimens, June, 1922. Somewhat unlike those described by Lauterbach (Engl. Bot. Jahrb. 58 Bd., 1–2 Heft. p. 20), the fruit in these specimens are globose or pyriform with a prominent depression around the stigma; they measure 4·5 cm. in diameter and are divided into 6–8 cells. The seeds are immature.

Garcinia assugu Lauterb. Veimauri Creek, 58, fruiting specimens, June, 1922; forests between Pernambata and Embi in the Hydrographers Range, 224, fruiting specimens, August, 1922.

Family DIPTEROCARPACEÆ.

Anisoptera polyandra Bl. Buna on the Ambogi River, 136, fruiting specimens, June, 1922; forests between Pernambata and Embi in the Hydrographers Range, 223.

Hopea papuana Diels. Vanapa River, about 12 miles above the village of Dora, 113, fruiting specimens, June, 1922.

Vatica papuana Dyer. Vailala River, 327, foliage specimens, December, 1922; Sudest (sent to C. E. Lane-Poole), 435, foliage specimens.

Family COCHLOSPERMACEÆ.

Cochlospermum Gillivræi Benth. Port Moresby, 434, flowering specimens, Baker (Jour. Bot. 61, Appendix p. 4, 1923) has named the common Port Moresby plant as a distinct variety (var. *papuana*). The leaves on Lane-Poole's No. 434 measure up to 11 cm. long on petioles up to 13 cm. The outer sepals in Queensland specimens are usually smaller than the inner, though not always so markedly as in the Papuan plant.

Family FLACOURTIACEÆ.

Homalium pachyphyllum Gilg. Vailala River, 334, flowering specimens, December, 1922.

Family DATISCACEÆ.

Octomeles sumatrana Miq. Veimauri Creek, 34, remains of dry flowers picked up from ground beneath the trees, September, 1922.

Family SONNERATIACEÆ.

Sonneratia alba Sm. On sand beach near Buna, 217, flowering specimens, July, 1922.

Family LECYTHIDACEÆ.

Planchonia timorensis Bl. Veimauri Creek, 2, in flower, June 1922.

Barringtonia speciosa Linn. Buna, sea beach just within reach of spring tides, 235, flowering specimens, August, 1922.

Barringtonia calyptrocalyx K. Sch. (?). Forests of the Lower Kumusi near Oititandi village, 191, flowering specimens, July, 1922. Differs from K. Schumann's description (Fl. Kaiser Wilhelm's Land, 91, 1889) in having broader leaves which are èntire on the margins and pubescent on the underside.

Barringtonia Forbesii Bak. fil. Vanapa, 122, flowering specimens, June, 1922.

Family RHIZOPHORACEÆ.

Rhizophora conjugata Linn. The coast near Buna, 213, flowering specimens, July, 1922.

Bruguiera Rheedii Bl. The coast near Buna, 212, flowering specimens, July, 1922.

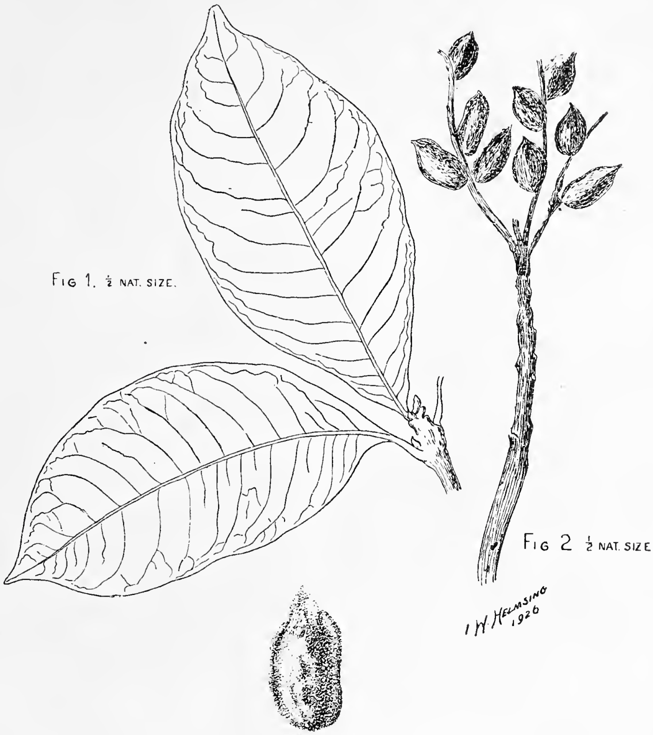
Family COMBRETACEÆ.

Terminalia foveolata sp. nov. (Text-figure 12).

Arbor 37 m. alta, partibus novellis ferrugineo-pubescentibus, ramulis teretibus. Folia alterna; petiolis 1–1·2 cm. longis supra minute ferrugineo-pubescentibus; laminis 4–5·5 cm. latis ca. 2 plo longioribus ellipticis oblanceolatis vel obovatis in sicco sub-nitidis sub-chartaceis subtus in axillis nervorum præcipuorum foveolatis basi angustis apice obtuse acuminatis, nervis lateralibus utrinque ca. 10, costa media et nervis et venulis et in pagina inferiore et superiore prominentibus.

Spicæ 5–6 cm. longæ ex axillis foliorum superiorum orientes. Flores non visi. Fructus (immaturus) compressus 1·8 × 1·1 × 0·6 cm. ovatus apice acutus vel acuminatus margine anguste alatus vel acute angulatus; pericarpio exiguo, endocarpio valde rugoso duro et ligneo.

Among Papuan species most closely allied to *T. complanata* K. Sch., from which it is distinguished by its glabrous leaves and non-glandular petioles.



Text-Figure 12.—*Terminalia foveolata* sp. nov. 1, leaf-bearing twig; 2, twig bearing fruiting spikes (the leaves have become detached); 3, fruit.

Baroi River. No. 285. Immature fruit gathered in October. A large tree with stem 15 feet in girth and 120 feet overall. Very heavily buttressed up to 15 feet.

Terminalia catappoides sp. nov. (Text-figure 13).

Arbor magna, partibus junioribus pilis ferrugineis vestitis. Folia ramulorum ad apices conferta, sessilia vel perbreviter petiolata; petiolis complanatis usque ad 3 mm. longis et latis; laminis 9–13·5 cm. latis 2·5 plo longioribus oblanceolatis ad apicem rotundatis vel subcordatis, apice ipso perbreviter acuminato, basin versus angustatis, basi ipsa anguste cordata vel auriculata, venis et venulis subtus prominentibus, costa media supra basin versus dense ferrugineo-pubescentibus, costis secundariis utrinque 18–23 plerumque angulo 80° de costa media adscendentibus, costa media

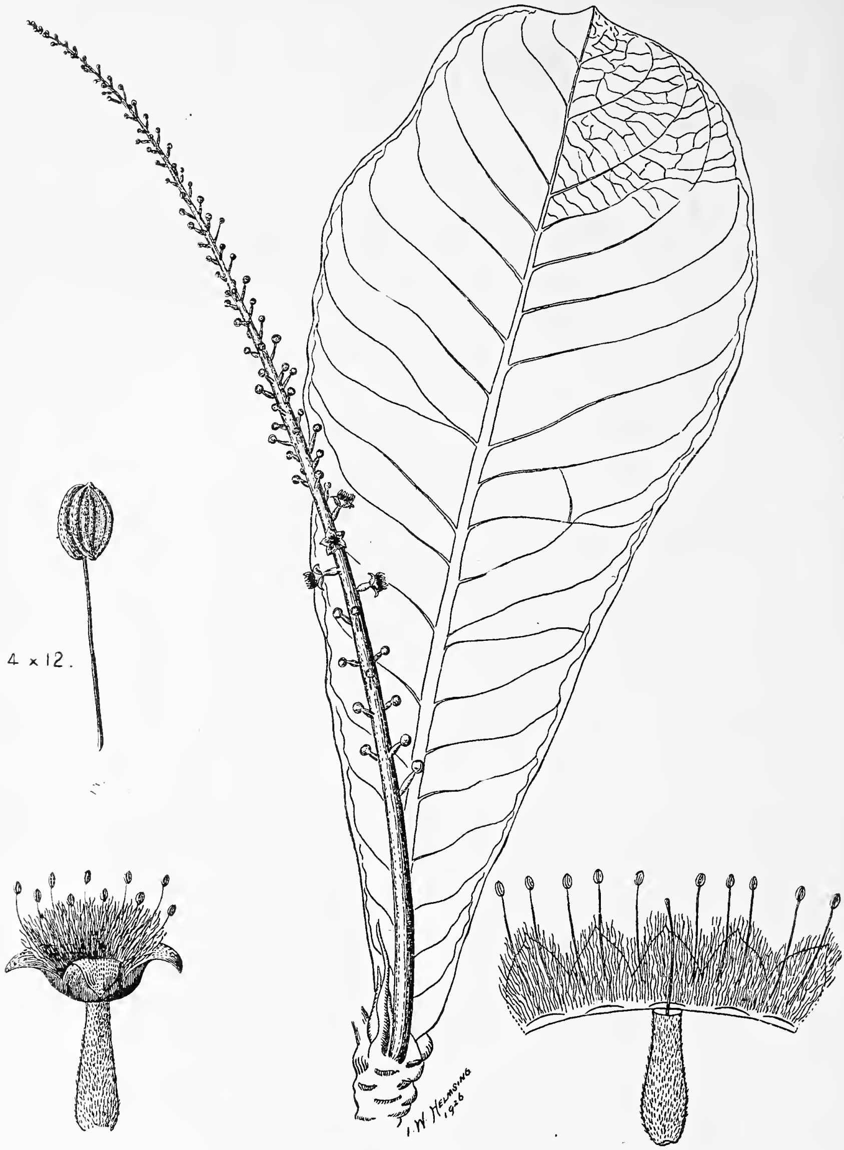


FIG 4 × 12.

FIG 2 × 4 FIG 1. ½ NAT SIZE FIG 3 × 4

Text-Figure 13.—*Terminalia catappoides* sp. nov. 1, flower-bearing shoot; 2, flower; 3, flower with calyx laid open, showing the stamens; 4, stamen.

et venis et venulis subtus in pagina inferiore dense ferrugineo-pubescentibus, lamina ceterum glabra. Spicæ axillares usque ad 30 cm. longæ, rhachide pubescenti. Flores hermaphroditi, spicæ in parte inferiore siti, calycis tubo extus in parte inferiore pubescenti, 6 mm. longo, limbo 5–6 mm. diam., parte integra extus puberula intus pilis longis vestita; lobis ovatis vel deltoideis, 1·5–2 mm. longis; stylo glabro tenuo 5 mm. longo. Flores masculi spicæ in parte superiore siti, pedicellati, pedicello usque ad 5 mm. longo, filamentis tenuis 4 mm. longis, antheris ovatis, basifixis 0·6 mm. longis. Fructus (in statu imperfecto modo visus) pericarpio suberoso 5 × 4 × 3 cm. sulcis ca. sex fibris farctis sulcato, endocarpio osseo.

Veimauri Creek. No. 36. A wide range all round Papua from sea level to 1,000 feet. A large tree 16 feet in girth with a bole of 80 feet and 130 feet overall. Stands leafless for about a month in the dry season (C. E. Lane-Poole).

Allied to *T. catappa* L., from which it is distinguished by its longer narrow leaves with more numerous primary nerves on each side of the midrib.

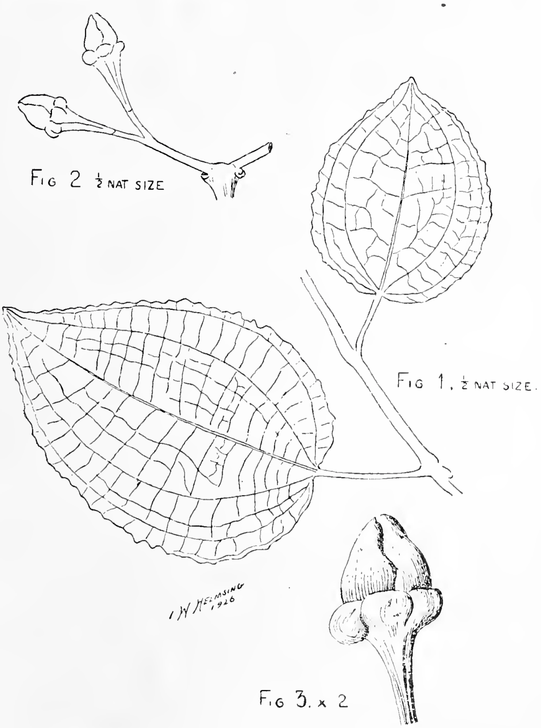
Family MYRTACEÆ.

Octamyrtus insignis Diels. Forests around village of Wasida and along the main path to Wire Rope, 163, flowering specimens. The specimens differ from Diels's description (Engler's Bot. Jahrb. 57 Bd. 3–5 Heft, 374) in having longer petioles, attaining 8 mm., and much narrower calyx lobes attaining only 6 mm. in breadth.

Family MELASTOMACEÆ.

Poikilogyne setosa sp. nov. (Text-figure 14).

Frutex, ramulis et petiolis et venis subtus et inflorescentiæ rhachide minutis setis dense vestitis. Ramuli teretes vel subquadrangulares. Folia opposita petiolata; petiolis 2–4 cm. longis; laminis 7–10 cm.



Text-Figure 14.—*Poikilogyne setosa* sp. nov. 1, part of branchlet; 2, part of inflorescence; 3, unopened flower.

longis, ca $1\frac{1}{3}$ plo longioribus quam latæ, cordatis ovatis margine denticulatis acuminatis tri vel quinquenerviis nervis et venis transversis et venulis in sicco utrinque visibilibus sed subtus prominentioribus et elevatis. Paniculæ terminales trichotomæ, pedicellis 5–7 mm. longis ad apicem bracteolis 2–3 minutis productis. Flores a nobis alabastra modo probabiliter visa) calycis tubo turbinato 7–9 mm. longo setis tenuis vestito, apicem versus 5–angulis vel tuberculis producto limbo obscure 5–lobato sinubus inter lobos angulas vel tubercula alternantibus; petalis glabris ovatis obtusis 4–5 mm. longis; staminibus 10 glabris, filamentis complanatis 2·5 mm. longis, antheris oblongis vel linearibus fere 5 mm. longis, stylo glabro tereti 5 mm. longo.

Mt. Obree at an elevation of 7,000 feet. No. 346. A shrub of scrambling habit, flowers lake-coloured.

Among previously described species most closely allied to *P. arfakensis* Bak. f., from which it differs in its cordate leaves and the absence of the dense golden brown indumentum from the upper surface of the leaves.

Family ARALIACEÆ.

Boerlagiodendron Sayeri Harms. Laruni Spur, Mt. Obree, 7,000 feet, 390, specimens bearing immature flowers, February, 1923.

Anomopanax philippinensis Harms. Mt. Obree to Laruni Spur, 7,000 feet, 388, flowering specimens, February, 1923. *Polyscias cibaria* W. and F. incd. in Lane-Poole, "Forest Resources, Papua and New Guinea," 129, 1925.

Family ERICACEÆ.

Agapetes Moorhousiana F. v. M. Forests between Pernambata and Embi in the Hydrographers Range, 222, flowering specimens, August, 1922.

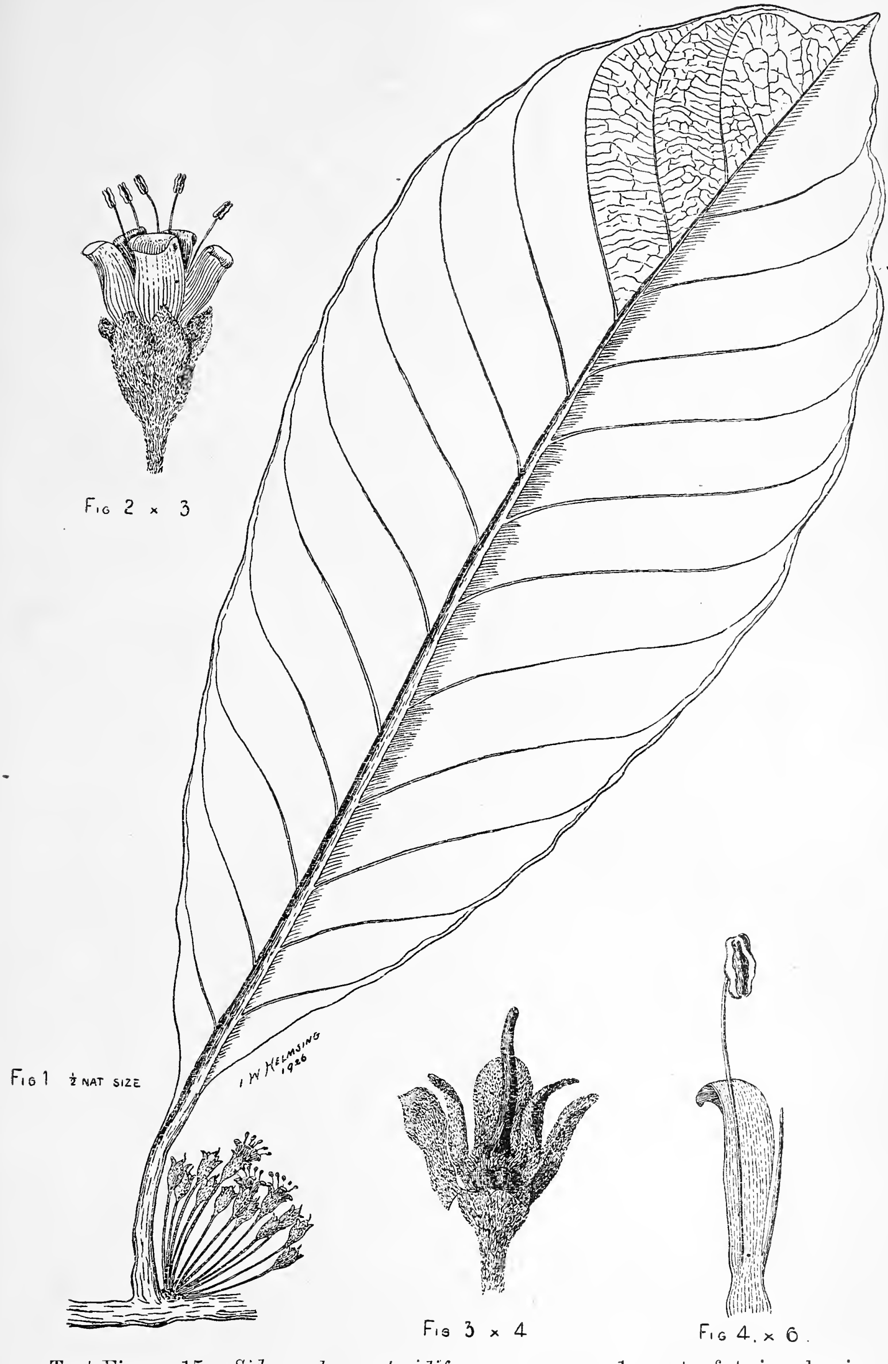
Family MYRSINACEÆ.

Ægiceras majus Gærtn. Buna, 233, flowering specimens, August, 1922.

Family SAPOTACEÆ.

Sideroxylon anteridiferum sp. nov. (Text-figure 15).

Arbor magna, ramulis pilis ferrugineis dense vestitis. Folia alterna, petiolata; petiolis ferrugineo-pubescentibus 4–5 cm. longis 3 mm. crassis; laminis 13–19 cm. latis ca. $2\frac{1}{4}$ plo longioribus obovatis apice rotundatis, apice ipso aliquando breviter acuminato, basi cuneatis, supra costa media et nervis lateralibus dense sed ceteram parce pubescentibus; subtus ubique densissime et breviter ferrugineo-pubescentibus, nervis lateralibus utrinque 12–16, costa et nervis et venulis transversis et in pagina superiore et inferiore visibilibus sed in pag. inf. elevatis et prominentioribus. Flores in fasciculis axillaribus dispositi, fasciculis 10–25 floris, pedicellis 1·5–2·5 cm. longis fere 1 mm. crassis; calyce dense



Text-Figure 15.—*Sideroxylon anteridiferum* sp. nov. 1, part of twig, showing leaf and inflorescence; 2, flower; 3, flower with calyx laid open and corolla removed, showing the ovary and style; 4, part of the corolla, showing a stamen.

pubescenti tubo campanulato 5 mm. longo lobis 5 imbricatis ovatis obtusis 2·5 mm. longis; corolla glabra tubo 3 mm. longo, lobis 5 oblongis obtusis 3–4 mm. longis, staminibus fertilibus 5 glabris lobis contra affixis et eos excedentibus, antheris ovato-oblongis 1·5 mm. longis, filamentis subulatis; staminodiis sub sinubus corollæ affixis et lobis brevioribus in parte superiore subulatis basin versus paulum expansis; ovario hemisphærico ad apicem pubescenti, stylo glabro 6–7 mm. longo.

Buna District, on the plain. No. 161. July, 1922. A large tree with stem 8 feet in girth with a 70-ft. bole, heavily buttressed. The specific name is derived from the large buttresses of the tree.

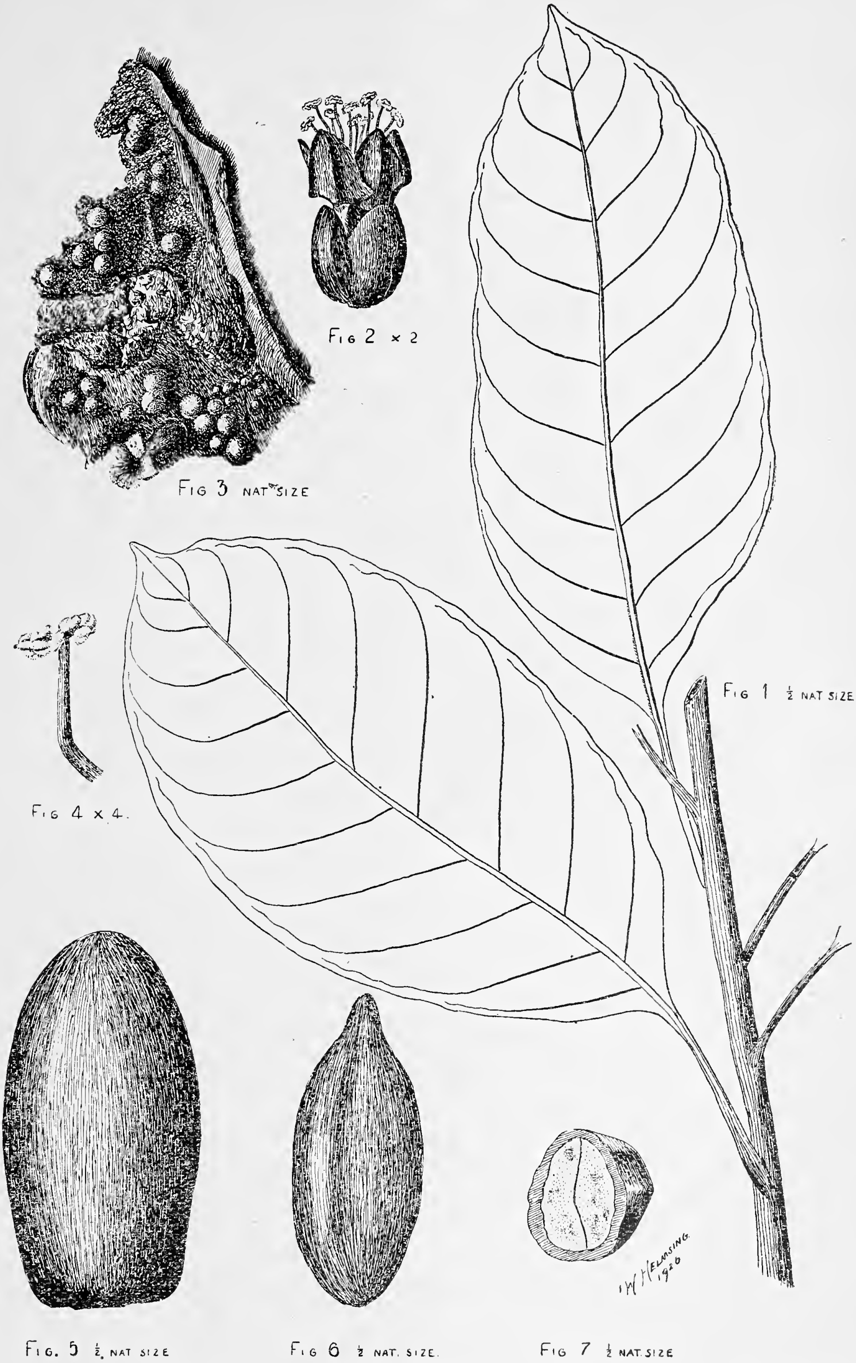
Achradotypus benefici sp. nov. (Text-figure 16).

Arbor parva, glabra (partibus junioribus non visis) ramulis teretibus. Folia alterna petiolata, petiolis 3–6 cm. longis laminis 6.5–12 cm. latis 2 plo longioribus ellipticis coriaceis breviter acuminatis ad basin cuneatis saepe per partem superiorem petioli decurrentibus, nervis lateralibus utrinque 8–10, costa media et nervis et venulis utrinque visibilibus sed in pagina inferiore multo prominentioribus. Flores albi e tumoribus in trunco orientes (tumoribus 8 cm. altis et 20 cm. diam.); pedicellis brevissimis vel 0; calycis lobis 5 imbricatis orbicularibus 6 mm. diam; corollæ tubo 6–7 mm. longo lobis ovatis vel late ellipticis obtusis 3–4 mm. longis; staminibus 10 in faucibus corollæ affixis eorum duobus lobis omnibus oppositis, filamentis teretibus 5–6 mm. longis, antheris horizontalis (?) et peltate affixis lanceolatis apiculatis 2·5 mm. longis margine undulatis, staminodiis vel squamis 5 sub sinubus corollæ affixis 3 mm. longis apicem versus expansis et in tres lobos divisis, lobo medio setaceo lobis lateralibus latis et ad apicem dentatis; pistillo 6 mm. longo glabro, ovario 5-loculari. Fructus atroviridis vel pæne niger ovoideus 9–10 cm. longus 5 cm. diam.; semine 8 $\times$ 3·2 $\times$ 2·8 cm. basi obtuso, cicatrice per totam longitudinem fereque dimidiam peripheriam extensa, testa nitida castanea 2–4 mm. crassa, albumine 0, radicula conica 7 mm. longa, cotyledonibus magnis et carnosis.

Embi in the Hydrographers Range. No. 227. Flowering and fruiting August, 1922. A small tree with stem 18 inches in girth and 150 feet high.

This little tree is the most feared sorcerers' tree in the Northern Division. Its appearance with the black fruit standing out at right angles to the stem is certainly remarkable and may possibly be the cause of its choice for sorcery purposes. So feared is it that I was unable to touch it, far less carry the specimens I collected, and it took some tact and some ingenuity to get away with them (C. E. Lane-Poole).

The specific name is derived from the fact that the species is a sorcerers' tree. The specimens were submitted to Dr. A. Guillaumin, of the Museum National d'Histoire Naturelle, Paris, for comparison with types of previously described species, and he replied that so far as he could see the species was entirely distinct from any previously-known ones. The genus was previously only known from New Caledonia.



Text-Figure 16.—*Achradotypus benefici* sp. nov. 1, part of leaf-bearing branchlet; 2, flower; 3, part of bark from stem of tree, showing buds and an expanded flower; 4, stamen; 5, fruit; 6, seed; 7, seed in transverse section.

Family SYMPLOCACEÆ.

Symplocos aggregata sp. nov. (Text-figure 17).

Arbor parva 9 m. in altitudine 45 cm. in circuitu (Lane-Poole); partibus novellis pubescentibus; ramulis glabris primum subangularibus deinde teretibus 3 mm. diam. infra apicem 10 cm. Folia alterna glabra in sicco flavescentes petiolata; petiolis 1·5–2 cm. longis; laminis 11–19 cm. longis 2–2½ plo longioribus quam latæ, obovatis vel oblanceolatis integris vel apicem versus minute serrulatis, basi cuneatis, apice acuminatis nervis lateralibus in utroque latere 3–6 utrinque visibilibus sed subtus multo

Text-Figure 17.—*Symplocos aggregata* sp. nov. 1; flower-bearing twig; 2, flower with calyx laid open and corolla and stamens removed, showing the ovary and style.

prominentioribus; venulis interdum subtus prominulis interdum pæne visibilibus. Inflorescentiæ axillares globosæ ca. 1 cm. diam.; floribus confertis albis et fragrantibus (Lane-Poole). Calycis tubus cupularis vel late campanulatus 4 mm. longus; lobis 5 orbicularibus marginibus tenuiter ciliolatis 2 mm. longis fere 3 mm. latis. Corollæ tubus 1–1·5 mm. longus; lobis 5 ovatis vel obovatis obtusis 5 mm. longis. Stamina 50 vel plura;

filamentis tenuis 4–5 mm. longis, antheris orbicularibus ·2–·3 mm. latis. Ovarium ad apicem 5 lobatis, lobis pubescentibus, stylo minuto, subconico glabro vel fere glabro, fere 1 mm. longo.

Forests of the Lower Kumusi River, near Oitatandi Village. No. 183. A small tree with stem 18 inches in girth, 30 feet high; bark grey, smooth, flowers white, fragrant. In rain forests as undergrowth.

Family LOGANIACEÆ.

Couthovia brachyura Gilg and Benedict. Buna on the Ambogi River, 138, flowering specimens, July, 1922.

Fagræa racemosa Jack. Forests around the village of Wasida and along main path to Wire Rope, 181, flowering specimens, July, 1922.

Family GENTIANACEÆ.

Limnanthemum indicum Thw. Embi Lake, Hydrographers Range, 251, flowering specimens, August, 1922.

Family APOCYNACEÆ.

Alstonia scholaris R.Br. Bank of Veimauri Creek, 29.

Alstonia longissima F.v.M. Vanapa River, 103, immature flowers, and empty follicles.

Voacunga papuana K.Sch. Page's Camp, Veimauri, 440, flowering specimens, May, 1922.

Family ASCLEPIADEÆ.

Hoya dimorpha F. M. Bailey. Foothills of the Hydrographers Range, 243, flowering specimens, August, 1922.

Family BORAGINACEÆ.

Cordia subcordata Lam. Port Moresby, near sea shore, 439, flowering specimens, April, 1922.

Family VERBENACEÆ.

Geunsia farinosa Bl. Forests around village of Wasida and along main path to Wire Rope, 167, flowering specimens, July, 1922.

Gmelina sessilis sp. nov. (Text-figure 18).

Arbor 34 m. alta (Lane-Poole) ramulis dense ferrugineo-pubescentibus sulcatis 5 mm. diam. ca. 10 cm. infra inflorescentiam. Folia opposita, petiolata; petiolis dense pubescentibus supra concavis subtus convexis 2–3 cm. longis; laminis coriaceis ovato-orbicularibus supra sparse subtus dense pubescentibus 12–22 cm. longis et fere æque latis vel laminis angustioribus 1½ plo longioribus quam latæ, apice obtusis vel rarius obtuse acuminatis, basi cordatis vel rotundatis margine late sinuatis vel integris, glandulis 1–3 ad basin utriusque lateris costæ mediæ, nervis lateralibus utrinque 7-9, nervis et venulis et in pagina superiore et inferiore prominentibus supra impressis subtus valde elevatis. Inflorescentia terminalis angusta et spiciformis 10–12 cm. longa 4 cm. lata, basi foliosa; cymulis

Text-Figure 18.—*Gmelina sessilis* sp. nov. 1, flower-bearing twig; 2, unopened flower. The dark spots on the calyx in 2 and on the bracts in 1 indicate glands.

oppositis vel cyclis, in parte inferiore inflorescentiæ interruptis, apicem versus confertis; bracteis exterioribus foliaceus magnis concavis ovatis extus dense pubescentibus et glandulis glabris atris punctatis, intus glabris; bracteis interioribus similibus sed parvis; bracteolis ovato-lanceolatis extus dense pubescentibus 7 mm. longis. Calyx campanulatus ferrugineo-pubescens, extus glandulis paucis glabris punctatus, intus glaber obscure bilabiatus vel margine sinuatus vel 3–4 lobatus, lobis latis. Corolla extus ad basin tubi glabra ceterum dense pubescens, intus tenuiter pubescens, 1·7 cm. longa (tubo ipso 1 cm. longo) bilabiata, labio superiore 2–lobato, labio inferiore 3–lobato. Filamenta pubescentes 7–9 cm. longa;

antheris basi cordatis apicem versus dorsifixis 1·5 cm. longis 1 mm. latis. Ovarium glabrum obovoideum ad apicem circa basin styli depressum; stylo pubescenti 1-6 cm. longo, apice recurvo.

Baroi. No. 303. A large tree with a stem girth of 8 feet and a bole of 70 feet, 110 feet overall, more or less buttressed to 8 feet.

Allied to *G. Dalrympleana* (F.v.M.) H. J. Lam and to *G. macrophylla* Wall. From the latter it differs in its narrow inflorescence, and from the former in its dense inflorescence.

Clerodendron Tracyanum F.v.M. Forests around village of Wasida and along main path to Wire Rope, 171, flowering specimens, July, 1922.

Clerodendron floribundum R.Br. Port Moresby, 437, flowering specimens, April, 1922.

Avicennia officinalis Linn. The coast near Buna, 211, flowering specimens, August, 1922.

Family BIGNONIACEÆ.

Diplanthera tetraphylla R. Br. Naro, 2,000 feet, one of the main streams adjoining the headwaters of the Brown River, 272, flowering specimens, August, 1922.

Family GESNERIACEÆ.

Æschynanthus discorensis Schltr. Ridge between Adai and Naro Rivers, 6,000 feet, East Central Division, 413, flowering specimens, February, 1923.

Æschynanthus nummularius K.Sch. Owen Stanley Range, 5,000 feet, 396, flowering specimens, February, 1923.

Cyrtandropsis monoica Lauterb. In ravines between Adai and Naro Rivers, 5,500 feet, East Central Division, 415, flowering specimens, February, 1923.

Family ACANTHACEÆ.

Acanthus ilicifolius Linn. Swamp at Buna, 258, flowering specimens, August, 1922.

Family RUBIACEÆ.

Hedyotis galioides F.v.M. Ridge dividing Adai and Naro Rivers, 6,000 feet, 412, flowering specimens, February, 1923.

Sarcocephalus cordatus Miq. Eight miles west of Buna, Northern Division, 158, foliage specimens.

Pavetta platyclada K.Sch. et Lauterb. Forests around village of Wasida and along main path to Wire Rope, 175, flowering specimens, July, 1922.

Morinda citrifolia Linn. Buna, 232.

Family CUCURBITACEÆ.

Trichosanthes bracteata Voigt. Open spaces in rain forests, Owen Stanley Range, 5,000 feet, 375, flowering specimens, February, 1923.

Family CAMPANULACEÆ.

Wahlenbergia gracilis A.DC. Grass Lands, Owen Stanley Range, 6,000–7,000 feet, 369, flowering specimens, February, 1923.

Family GOODENIACEÆ.

Scævola novo-guineensis K. Sch. Owen Stanley Range, 6,000 feet, on the edge of forest and grass land, 371A, flowering specimens, February, 1923.

Family COMPOSITÆ.

Vernonia arborea Hamlt. Iorobaiva, 3,000 feet, Central Division, 429, flowering specimens, February, 1923.

Olearia vernonioides sp. nov. (Text-figure 19).

Text-Figure 19.—*Olearia vernonioides* sp. nov. 1, flower-bearing twig; 2, flower; 3, disk floret; 4, ray floret.

Frutex 2·7 mm. altus (Lane-Poole), partibus junioribus et ramulis et foliis subtus et inflorescentiæ rachide dense pubescentibus; indumento colore variabili, in partibus junioribus ferrugineo in foliis primum flavido deinde albido. Ramuli striati vel leviter costati. Folia petiolata; petiolis pubescentibus 6–10 mm. longis; laminis 6–9 cm. longis 2½–3 plo longioribus quam latæ, oblanceolatis, in parte superiore late et obscure denticulatis, apice obtusis vel subacutis, basin versus sensim cuneatis sed basi ipsa leviter rotunda, nervis lateralibus in utroque latere 10–12 fere horizontalis supra in sicco visibilibus sed non distinctis; costa media et nervis lateralibus et venulis subtus prominentibus et valde elevatis. Paniculæ corymbosæ ex axillis superioribus orientes folia æquantes vel fere æquantes, pedunculo usque ad 2·3 cm. longo; ramulis ad basin bracteatis, bracteis infimis foliaceis usque ad 3 cm. longis; pedicellis 2-10 mm. longis bracteatis, bracteis linearibus 2–3 mm. longis. Capitula ca. 1·5 cm. lata et 1 cm. alta, involucri bracteis angustis linearibus 0·5–1 mm. latis margine ciliolatis, apice obtusis vel subacutis, seriei exterioris bracteis longis, seriei interioris bracteis usque ad 5 mm. longis; flosculis 20–30; radii flosculis ca. 10; corollæ tubo 2 mm. longo, ligula spathulata 5 mm. longa, stylo exserto; disci flosculis corollæ tubo 4 mm. longo, limbo 5-lobato, lobis ca. 1 mm. longis, stylo exserto, hujus ramis duobus in dorso rotundis vel convexis in facie interiore planis. Æchinia cylindracea puberula 1·7 mm. longa, pappi setis ca. 30, 3–4 mm. longis, tenuiter barbellulatis.

Owen Stanley Range at an altitude of 6,000 feet. Flowering on 23rd February. No. 368. A shrub, flowers white; Owen Stanley Range, 7,400 feet, flowering specimens, February, No. 359.

This species differs from *O. exilis* S. Moore in its alternate broadly dentate leaves and from *O. monticola* Bail. by its longer and narrower leaves.

A New Species of *Nitella* (Characeae) from Southern Queensland.

By James Groves, F.L.S. (Isle of Wight, England).

(*Communicated by C. T. White, Government Botanist, Brisbane, 25th October,* 1926.)

NITELLA PHAULOTELES, sp. nov.

Sect. Homœoclemæ arthrodactylæ vicellulatæ flabellatæ macrodactylæ gymnocephalæ monoeciæ.

Stem c. 450 μ in diameter. Branchlets normally 6 in a whorl, varying greatly in length in the same whorl, the fertile 2–3, sometimes 4 times forked; primary ray $\frac{1}{3}$–$\frac{1}{2}$ the length of the entire branchlet, secondary rays usually 4, tertiary 2–4, quaternary and quinary usually 2, the rays at each furcation conspicuously unequal; final rays (dactyls) uniformly 2-celled, the lower cell of moderate length, not tapering but rounded at the distal extremity, upper cell very small bluntly conical. Gametangia produced somewhat irregularly at all the branchlet-nodes, but oogonia and antheridia rarely at the same node. Oogonia solitary 400–450 μ long, c. 375 μ broad; coronula c. 30 μ high, 60 μ broad. Oospore golden-brown, c. 275–300 long, 240–265 μ broad, 175–200 μ thick, showing 6–7 strong high ridges; membrane apparently without decoration. Antheridium c. 400 μ in diameter.

Doomben, near Brisbane, E. W. I. Buhot.

The specimens show a small plant of lax habit, the whorls attaining a diameter of about 15 mm. From the material available it has not been found practicable to describe the lower sterile whorls, but it is hoped that further specimens will be forthcoming to allow of an ampler description. The outstanding features appear to be, the remarkably irregular length of branchlets and rays, and the very small bluntly-conical ultimate cells. I have not been able to detect any decoration on the oospore-membranes examined. The dimensions given for fruits, &c., are the result of several measurements in each case, but should be regarded as a merely approximate guide, as with these plants there is, in this respect, usually considerable variation in different individuals.

The Royal Society of Queensland.

Report of Council for 1925.

To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its Report for the year 1925.

During the year ten papers were read and discussed before the Society and published. The following lectures, which were well attended and to which the public was invited, were delivered:—"A Naturalist in Central Africa," by Mr. Chas. Hedley; "Huxley: Personal Characteristics," by Mr. H. A. Longman; "Huxley, the Biologist," by Prof. E. J. Goddard; "Huxley, the Educationalist," by Prof. J. P. Lowson. The three last-mentioned lectures were delivered at a meeting celebrating the Huxley Centenary.

The Council wishes to acknowledge a generous subsidy of £130 from the Queensland Government towards the cost of printing the Proceedings of the Society. Appreciative acknowledgment is also made to the University of Queensland for housing the library and providing accommodation for meetings.

The membership roll consists of 166 ordinary members, eight corresponding members, seven life members, and five associates. During the year two members resigned and one corresponding member, one life member, and three ordinary members died. The number of new members elected amounted to twenty-four, consisting of nineteen ordinary members and five associates.

The deaths of Mr. J. H. Maiden, I.S.O., F.R.S. (corresponding member), Mr. Thos. Steel (life member), and Mr. K. ff. Swanwick, B.A.. LL.B. (ordinary member) are reported with regret. J. Douglas Ogilby, who was widely known as an ichthyologist and who contributed several papers to this Society, passed away on the 11th August, 1925, after a lengthy illness, at the age of seventy-two.

There were nine meetings of the Council. The attendance was as follows:—E. W. Bick 8, W. H. Bryan 5, J. V. Duhig 6, W. D. Francis 9, E. J. Goddard 4, R. W. Hawken 6, D. A. Herbert 8, H. A. Longman 7, E. O. Marks 9, H. J. Priestley 5, H. C. Richards 7, C. T. White 7.

The exchange list of the Society's Library has been considerably extended by the addition to it of a large number of foreign institutions. This will be the means of extending the circulation of the publications of the Society and increasing the number of contributions to the library.

The Annual Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 29th March, 1926.

The President, Prof. R. W. Hawken, B.A., M.E., M. Inst. C.E., in the chair.

The minutes of the previous annual meeting were read and confirmed.

On the motion of Prof. J. P. Lowson the annual report and financial statement were adopted.

The following Officers were elected for 1926 :—

President : Dr. J. V. Duhig, M.B.

Vice-Presidents : Prof. R. W. Hawken, B.A., M.E., M.Inst C.E. (*ex officio.*)

Prof. E. J. Goddard, B.A., D.Sc.

Hon. Secretary : Mr. W. D. Francis.

Hon. Treasurer : Mr. E. W. Bick.

Hon. Editor : Mr. H. A. Longman, F.L.S.

Hon. Librarian : Mr. D. A. Herbert, M.Sc.

Hon. Auditor : Prof. H. J. Priestley, M.A.

Members of the Council : Dr. C. D. Gillies, M.B., B.S., M.Sc., Dr. E. O. Marks, B.A., B.E., M.D., Prof. H. J. Priestley, M.A., Prof. H. C. Richards, D.Sc., and Mr. C. T. White, F.L.S.

Messrs. R. Veitch, B.Sc., J. K. Murray, B.A., B.Sc., and R. B. Morwood, B.Sc., were nominated for ordinary membership and Mr. E. C. Tommerup as an associate.

Mr. F. F. Coleman was unanimously elected as an ordinary member.

Dr. J. V. Duhig was inducted to the position of President for 1926.

The retiring President, Prof. R. W. Hawken, delivered his address entitled "The Location of City Bridges." The various sites examined and reported upon were illustrated upon a model of Brisbane and the Brisbane River, a large wall map, and lantern slides. The results of many of the inquiries and analyses made by the Cross River Commission (of which the lecturer is President) were outlined.

On the motion of Dr. E. O. Marks, seconded by Prof. Richards, a vote of thanks was accorded the lecturer for his address.

THE ROYAL SOCIETY OF QUEENSLAND.

Cr. STATEMENT OF RECEIPTS AND EXPENDITURE FOR YEAR ENDING 31ST DECEMBER, 1925. **Dr.**

Receipts.	£	s.	d.	Expenditure.	£	s.	d.
Bank Balance, 31st December, 1924	12	13	8	Government Printer—			
Subscriptions	152	5	0	Stationery Account	10	12	3
Government Subsidy (Printing Account)	130	0	0	Printing Account	260	15	9
Extra Reprints and Blocks	42	7	0	Hon. Secretary (Postages)	11	0	0
Sale of Volumes	0	17	9	Hon. Librarian (Postages)	1	10	0
Exchange	0	4	6	Hon. Treasurer (Postages)	2	0	0
				Advertising Lectures	3	1	3
				Assistance in Library (C. Illidge)	3	3	0
				State Government Insurance	0	14	5
				Bank Charges	0	10	0
				Cheque Book	0	5	0
				Exchanges	0	5	8
				Balance in Bank, 31st December, 1925	44	10	7
	£338	7	11		£338	7	11

Examined and found correct.
H. J. PRIESTLEY,
Hon. Auditor, 3rd March, 1926.

E. W. BICK, Hon. Treasurer.

The Royal Society of Queensland.

Abstract of Proceedings, 28th April, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Wednesday, 28th April, 1926.

The President, Dr. J. V. Duhig, M.B., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Messrs. R. Veitch, B.Sc., J. K. Murray, B.A., B.Sc., and R. B. Morwood, B.Sc., were unanimously elected as ordinary members.

Mr. H. A. Longman exhibited an exceptionally large human mandible, received from Mr. H. A. Craig, Rockhampton. This specimen was in some respects the largest jaw yet found in Queensland, but the records for Australian aboriginals were exceeded by some races, such as the Esquimaux, and were, of course, far below the Heidelberg fossil. A few dimensions were given:—Coronoid height 79 mm., condylar height 72, breadth of ascending ramus 42·5, intercondylar breadth (external) 125, intergonal breadth 116, breadth of dental arcade outside first molars 68.

Mr. O. A. Jones, B.Sc., exhibited:—(1) Volcanic tuff from Mount Crosby. This is a greenish tuff similar to the Brisbane tuff and on the same horizon. It is interbedded with shales containing Ipswich fossils and the outcrop is much farther west than any previously recorded. (2) Fossil insects from Mount Crosby. Two good specimens were obtained from the shales immediately above the tuff referred to in the previous exhibit. They are of a new genus and species allied to *Triassoblatta insignita*. The horizon is almost at the base of the Ipswich series.

Dr. E. O. Marks, B.A., B.E., exhibited a fragment of trachyte found in the sandstone at Dunwich (Bundamba). If the trachyte is found to be similar to that of the Glasshouse Mountains, it would suggest the possible Tertiary age of the sandstone in which it was found.

Prof. H. C. Richards, D.Sc., exhibited a specimen of olivine basalt from the Galah Gorge, near Hughenden, which was handed to him by Mr. A. F. Partridge. This basalt exhibits flower-like structures which probably resulted from cooling phenomena.

Dr. F. W. Whitehouse exhibited:—(1) A new species of *Redlichia,* including one specimen of enormous size, from the Cambrian beds of

Flora Downs, North-west Queensland. (2) Specimens of the Devonian *Phragmoceras subtrigonum* McCoy from the Golden Valley limestone, North Queensland, and the Carboniferous *Cactocrinus brownii* Dun and Benson from Malchi Creek, Central Queensland. These represent Australian species not hitherto recorded from Queensland.

The President, Drs. Bryan and Marks, Prof. Richards, and Mr. Longman commented upon the exhibits.

A paper by Mr. W. B. Alexander, M.A., entitled "Variation of the Acclimatised Species of Prickly Pear (*Opuntia*)," was communicated by Mr. C. T. White. Nine species of *Opuntia* are mentioned as pests in Australia and are enumerated in the Bulletin issued by the Commonwealth Prickly Pear Board ("The Prickly Pears Acclimatised in Australia," p. 3, 1925). No variations in *O. aurantiaca, O. vulgaris, O. streptocantha,* and the Joconoxtle (which are included in the nine pest pears) were met with. The variations met with among the other species of pest pears are grouped under the heads of fluctuations, mutations, and hybrids. Messrs. Gurney and Longman commented upon the paper.

Mr. O. A. Jones, B.Sc., read a paper entitled "The Tertiary Deposits of the Moreton District of South-eastern Queensland." The occurrence, areal distribution, and palæontology of the deposits are described or outlined. Other features dealt with include the economic properties, age, climate, and earth movements of the deposits. Two divisions are recognised—(1) The Oxley, Redbank, and Ipswich Beds, and (2) the Bald Hills, Petrie, and Redcliffe Beds. The President, Mr. Longman, Prof. Richards, and Drs. Whitehouse and Marks commented upon the paper.

Abstract of Proceedings, 31st May, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 31st May, 1926.

Professor R. W. Hawken, B.A., M.E. (Vice-President) in the chair.

Mr. E. C. Tommerup was unanimously elected as an associate.

Dr. F. W. Whitehouse, M.Sc., exhibited :—(1) The unfigured holotypes of *Beudanticeras flindersi* McCoy, *Dimitobelus diptycha* McCoy from the Tambo Series, and "*Micraster Sweeti* Eth. fil." from the Maryborough beds of the Queensland Cretaceous. The echinoid, being associated with Lower Aptian species, cannot be a *Micraster*, but specimens are not sufficiently well preserved to determine the correct genus. (2) New species of *Ancyloceras* (s. str.) from Morven and two miles north of Wallumbilla, and of *Ammonitoceras* from five-and-a-half miles east of Tambo. These represent genera new to Australia and are associated with species of the basal and uppermost horizons respectively of the Roma Series. (3) Specimens of *Microdiscus elkedraensis* Eth. fil. from the Cambrian beds of Yelvertorf Station (N. W. Queensland). The species has been recorded previously only from the type locality in the Northern Territory.

A paper by Dr. T. L. Bancroft, entitled "The Apparent Twist in the Cotton Fibre an Optical Illusion," was communicated by Mr. W. D. Francis. After examination of cotton fibres with very high powers of the microscope the author concludes that almost all of the apparent twists were not twists but the edges of the flattened tube in close position. The paper was commented upon by Mr. W. G. Wells (a visitor).

A paper by Count Prof. U. Martelli, entitled "A New Species of Pandanus from North-West Queensland," was communicated by Mr. C. T. White. The species was found along perennial streams about 200 miles south-west of Burketown by Mr. A. de Lestang, after whom the species has been named *Pandanus De Lestangii*, and is the only Australian representative of the section Hombronia of the genus. Mr. F. Bennett commented upon the paper.

Mr. E. W. I. Buhot read a paper entitled "Effects on Mosquito Larvæ by a Queensland Species of Nitella (*N. phauloteles* J. Groves, M.S.). Mosquito larvæ failed to appear in an aquarium in which this species was growing, although mosquitoes were introduced into a screened area which included the surface of the water in the aquarium. In two other adjacent aquaria containing water from the same source mosquitoes bred freely. Drs. Hamlyn Harris and E. O. Marks and Messrs. C. T. White, F. Bennett, and W. D. Francis took part in the subsequent discussion.

Abstract of Proceedings, 28th June, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 28th June, 1926.

The President, Dr. J. V. Duhig, M.B., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. W. D. Francis read a paper entitled "The Development of the Corrugated Stems of Some Eastern Australian Trees." Two classes of corrugated stems are recognised: fluted or grooved stems (exemplified by *Villaresia Moorei*), and wrinkled or finely corrugated woody cylinders (exemplified by *Arytera Lautereriana*). The development of the stems of these two species and the anatomy of the wood connected with the grooves and wrinkles are described and illustrated. In addition, the anatomy of the wood associated with the wrinkled woody cylinders of *Sarcopteryx stipitata, Cryptocarya corrugata, Canthium latifolium,* and *Casuarina inophloia* is described and illustrated. Messrs. H. Tryon and D. A. Herbert commented upon the paper.

Mr. E. Ballard, B.A. delivered a lecture on "A Journey Up the Markham Valley, New Guinea." The head waters of the Markham and its tributaries are little known. The floor of the valley slopes gently to the west, and rises gradually from sea-level to an elevation of 1,250 feet. The valley about half-way up changes direction abruptly through a few degrees, and runs rather more northerly than north-westerly. It is generally supposed that the Markham Valley owes its origin to a fault, and that at one time the Huon Peninsula was an island. During this time the sandstones and conglomerates which form the foot hills of the valley were formed. The subsequent uplift was very rapid, and the valley passed from sea strait to estuary to its present status of a valley. Messrs. C. T. White, B. Dunstan, C. Massey, H. Tryon, H. A. Longman, E. W. Buhot, and Dr. E. O. Marks took part in the discussion on the lecture.

Dr. W. H. Bryan exhibited a specimen of green banded jasper containing remains of radiolaria from New England, in New South Wales. Mr. H. Tryon commented upon the exhibit.

Abstract of Proceedings, 26th July, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 26th July, 1926.

Prof. E. J. Goddard, B.A., D.Sc., Vice-President, in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Dr. W. H. Tilling and Mr. S. Stephenson, M.A., were nominated for ordinary membership.

The Chairman extended the best wishes of the Society to Mr. Owen Jones, B.Sc., who is about to leave for a post-graduate science course at Cambridge University.

Mr. H. A. Longman, F.L.S., exhibited the symphyseal portion of mandible with remains of two incisors of *Diprotodon minor* Huxley. The specimen was obtained near Murgon, South Burnett, and handed to Rev. C. H. Massey, by whom it was donated to the Queensland Museum.

Prof. H. C. Richards, D.Sc., communicated a paper by Capt. J. A. Edgell, R.N., entitled "Report on Solar Phenomenon Observed by H.M.A.S. 'Moresby' on Wednesday, 4th November, off the East Coast of Queensland." The paper describes and illustrates a halo around the sun observed near Keppel Island.

Dr. W. H. Bryan, M.C., read a paper entitled "The Earlier Palæogeography of Queensland." The author discussed the several views as to the shape and extent of the primeval Australasian continent, and with the aid of lantern slides traced the history of its growth period by period through the Palæozoic Era. Throughout the whole of this time the western half of Australia remained a land mass, while on the other hand much of Eastern Australia was covered by a succession of seas. To the east of these again in the positions now occupied by the Coral and Tasman seas, and possibly extending as far as New Caledonia and Fiji, there probably existed a great land mass which has been lost to Australia by a series of foundering movements which may have begun in Permian times. Thus the Palæozoic seas of Eastern Australia would appear to have been elongate and limited by land masses on each side just as the Mediterranean Sea is at the present day.

Dr. F. W. Whitehouse, M.Sc., read a paper by Dr. W. H. Bryan, M.C., and himself entitled "The Later Palæogeography of Queensland," The authors show on their map a greater extent for the Triassic lakes (in which the Ipswich Coal Measures were deposited) than has been recognised previously. Evidence is given indicating that, during the period of deposition of the Walloon Coal Measures, several transient incursions of the sea took place in the area. During the succeeding (Cretaceous) period the sea occupied the central portion of the continent extending, apparently, from the Gulf to the Bight. Continuous deposition was arrested by a temporary return to land conditions before the final stage of flooding by the sea. The close of the Cretaceous marked a return to lake conditions. The deposits of the Tertiary period are known only from isolated areas, all more or less near the east coast, the precise extent of the lakes in which they were formed being unknown. It is suggested, however, that during the Tertiary period the shore line was not far from its present position.

Dr. E. O. Marks, Prof. H. C. Richards, and Messrs. A. K. Denmead, C. Ogilvie, H. A. Longman, C. H. Massey, and Prof. E. J. Goddard commented upon the papers.

Abstract of Proceedings, 30th August, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th August, 1926.

The President, Dr. J. V. Duhig, M.B., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Dr. W. H. Tilling and Mr. S. Stephenson, M.A., were unanimously elected as ordinary members.

Dr. L. S. Bagster exhibited samples of leather tanned with syntan, mangrove bark extract, mixtures of syntan and mangrove bark extract, and leather tanned with mangrove bark extract and bleached by treatment with syntan. It was stated that the syntans or synthetic tanning materials were discovered by Stiasny and several of them were patented in Austria and Germany. They are prepared by reaction between various coal tar products, such as cresol, and sulphuric acid and formaldehyde. When the syntans are used alone a white leather is produced. A further important property of the syntans is their power of dissolving the dark colouring matters associated with vegetable tanning extracts such as those of mangrove barks. In consequence of this property, the syntans when used in conjunction with mangrove extract, produce a much lighter coloured leather than that made with mangrove extract alone.

Professor H. C. Richards exhibited samples of material from the bore which was put down by the Great Barrier Reef Committee at Oyster Cay near Cairns. The bore attained a depth of 600 feet. The great majority of the material down to 400 feet consisted of broken coralline detritus. Some solid coral core was encountered between 10 and 17 feet from the surface. From 400 to 600 feet the material was non-coralline and composed to a great degree of rounded grains of quartz sand. The exhibitor stated that a cursory survey of the material from the bore seemed to indicate decisive evidence of subsidence which would substantiate Darwin's hypothesis of the origin of coral islands.

Dr. E. O. Marks exhibited a geode containing zeolites and lined internally with chalcedony. The specimen was obtained from Nanango.

Mr. H. A. Longman exhibited a juvenile specimen of the "Luth" or "Leathery Turtle," *Dermochelys coriacea* from the Solomon Islands, which had been presented to the Queensland Museum. He also showed a sketch of a large specimen of this turtle which had been captured by some of the islanders off Anchor Bay in the Torres Strait. The sketch was forwarded by the Rev. W. H. MacFarlane, of Thursday Island, through Mr. Chas. Hedley. The sketch and the description accompanying it left no doubt as to the identity of this giant turtle, which was said to be about 8 feet 6 inches in length and was known to the natives by the name of "Zignaipu."

Messrs. Longman, C. T. White, B. Dunstan, and Drs. E. O. Marks and L. S. Bagster commented upon the exhibits.

Mr. C. T. White communicated a paper by the late J. H. Maiden and Mr. W. F. Blakely entitled "Descriptions of Seven New Queensland Acacias and One New Variety." The following new species are described and illustrated: *Acacia angusta, A. semirigida, A. pustula, A. attenuata, A. semilunata, A. jucunda, A. glaucocarpa. Acacia stipuligera* F. v. M. var. *glabrifolia* is described as a new variety.

A paper by Mr. G. H. Hardy entitled "Notes on Tasmanian Flies of the Genus *Atherimorpha*" was taken as read. The paper deals with a genus of the Leptidae originally described from Tasmania of which two species are now known and three forms of one of these species are recognisable by slight structural and colour characters.

The President, Messrs. D. A. Herbert, and H. A. Longman commented upon the paper by the late J. H. Maiden and Mr. W. F. Blakely.

Abstract of Proceedings, 27th September, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 27th September, 1926.

The President, Dr. J. V. Duhig, M.B., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Dr. W. H. Bryan exhibited Permo-Carboniferous fossils from Cressbrook Creek. These prove the existence of a hitherto unsuspected area of Permo-Carboniferous rocks. The fossils included *Trachypora wilkinsoni, Monilopora nicholsoni, Zaphrentes sp., Strophalosia sp., Mourlonia sp., Pleurotomaria sp.,* and *Conularia sp.* In fossil content, lithological character, and association with acid volcanic rocks, the new area can be closely correlated with the Condamine Beds of the Silverwood-Lucky Valley area.

Dr. E. O. Marks exhibited pebbles of igneous rocks from sandstone at Deception Bay. These pebbles suggest a Tertiary Age for the sandstone or Mesozoic igneous activity.

Mr. A. K. Denmead exhibited, on behalf of Rev. C. H. Massey, a number of rock specimens apparently of the Brisbane Schist Series which were obtained from Kanaipa Point, Russell Island, Macleay Island, and Stradbroke Island. These prove that the Brisbane Schist Series is more extensive in the southern part of Moreton Bay than had been supposed, and suggest that other adjacent areas which are assumed to represent more recent series may prove to be in part made up of deeply weathered Brisbane schists.

Professor Richards and Drs. Bryan and Whitehouse commented upon the exhibits.

Mr. A. P. Dodd read a paper entitled "The Genus *Scelio* Latreille in Australia (Hymenoptera: Proctotrypoidea)." The author recognises twenty-nine species. The following new species are described:—*Scelio concinnus, S. fulvithorax, S. sulcaticeps, S. perspicuus, S. improcerus, S. pilosifrons, S. contractus, S. asperatus, S. notabilis, S. amoenus, S. nigrobrunneus, S. ignobilis, S. planithorax.* Mr. H. Tryon and Prof. Goddard commented upon the paper.

Mr. H. Tryon read a paper entitled "Queensland Fruit Flies (Trypetidæ), Series I." The following new species are described:—*Chætodacus fagræa, C. halfordiæ, C. bryoniæ, C. barringtoniæ, C. musæ, C. bancrofti, C. jarvisi, Dacus signatifer, D. niger, Rioxa araucariæ, R. jarvisi,* and *Bactrocera pulcher.* The following species are recorded for the State:—*Chætodacus dorsalis* Hendel, *Bactrocera caudatus* (Fabr.) Bezzi. For *Chætodacus tryoni* Froggatt, twenty-nine hosts included in twenty-two families of indigenous fruits and forty-three hosts included in eighteen families of naturalised economic fruits are enumerated. Prof. Goddard commented upon the paper.

On the motion of Prof. Richards, seconded by Mr. H. Tryon, the Society's sympathy with the widow of the late Charles Hedley was expressed. Appreciative acknowledgment of Mr. Hedley's notable work for the general advancement of scientific knowledge and in connection with the activities of the Great Barrier Reef Committee was also made.

The development of Permo-Carboniferous beds in Queensland was the subject of a discussion towards the conclusion of the meeting. Drs. Whitehouse and Bryan, Mr. J. H. Reid, Prof. Richards, and the following visitors (Profs. Benson and Leo. Cotton and Mr. E. C. Andrews) took part in the discussion.

Abstract of Proceedings, 25th October, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 25th October, 1926.

The President, Dr. J. V. Duhig, M.B., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. J. Legg, B.Sc., M.R.C.V.S., and Rev. W. P. H. Hubbard were proposed as ordinary members.

The reports of the Society's delegates (Mr. E. W. Bick and Dr. F. W. Whitehouse) to the Perth meeting of the Australasian Association for the Advancement of Science were submitted. On the motion of Prof. Richards, seconded by Dr. E. O. Marks, a vote of thanks to the delegates was passed, and it was suggested that an account of the organisation of the Perth meeting might be helpful in making arrangements for the Brisbane meeting.

Prof. H. C. Richards exhibited a sample of fossil wood from the Petrified Forest, California, presented to the Geology Department of the University by His Grace Archbishop Duhig.

Mr. H. A. Longman exhibited photographs of aboriginal rock carvings on the flat sandstone bed of a creek about 62 miles from Hughenden. The photographs were presented to the Queensland Museum by Mr. J. R. Trundle, of Hughenden.

A paper by Mr. James Groves entitled "A New Species of *Nitella* from South Queensland" was communicated by Mr. C. T. White. *Nitella phauloteles,* the new species, is described. It was collected in the neighbourhood of Brisbane by Mr. E. W. Buhot.

Mr. C. T. White read a paper by himself and Mr. W. D. Francis entitled "Plants Collected in Papua by C. E. Lane-Poole." Mr. White outlined some of the general features of the flora of Papua. In the paper the following new species are described:—*Cyathacalyx polycarpum, Albizzia fulva, Flindersia macrocarpa, Dysoxylum fissum, Aglaia obliqua, Elaeocarpus comatus, Columbia aequilateralis, Pterocymbium stipitatum, Wormia quercifolia, Saurauja plurilocularis, Saurauja vallium, Saurauja Poolei, Terminalia foveolata, Terminalia catappoides, Poikilogyne setosa, Sideroxylon anteridiferum, Achradotypus benefici, Symplocos aggregata, Gmelina sessilis,* and *Olearia vernonioides.* Messrs. D. A. Herbert and J. E. Young commented upon the paper.

ABSTRACT OF PROCEEDINGS, 29TH NOVEMBER, 1926.

The ordinary monthly meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 29th November, 1926.

Professor R. W. Hawken, B.A., M.E., Vice-President, in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. G. H. Barker was nominated as an ordinary member.

Mr. J. Legg, B.Sc., M.R.C.V.S., and Rev. W. P. H. Hubbard were unanimously elected as ordinary members.

Mr. H. A. Longman exhibited (1) a paratype of a new rodent from "Cowan Cowan," Moreton Island, collected by Mr. J. Edgar Young for the Queensland Museum, which had been named *Rattus youngi* by Mr. Oldfield Thomas; (2) embryo from *Pteropus poliocephalus*, taken from this "flying-fox" in Brisbane on 18th October; when unfolded this embryo had a wing-stretch of 14 inches; (3) pelvic girdles from *Pteropus poliocephalus*, illustrating male types with the symphysis firmly ankylosed and female types with widely-open pubes; (4) a small venomous snake, *Furina annulata*, which had been partly swallowed by a slightly larger specimen of *Denisonia nigrescens*.

Mr. H. Tryon exhibited cores of black, pale grey, pale brown, and grey-reddish, banded quartzite and massive vitreous quartz, each showing evidence of having been submitted to the napping process. He also exhibited "knives" and "scrapers" of these rocks and of red quartzite. In some instances these implements were evidently derived from smooth boulders. The implements were discovered by Mr. Tryon at the sites of ancient camps of aboriginals on Russell Island, Moreton Bay. He pointed out that an examination of natural exposures and sections exposed in wells indicated that none of the above rock varieties were of local origin. This applied also to primitive "mullers," all composed of a vesicular quartz, that were met with in the same area. There were local evidences that these artifacts had been manufactured in situ from stone supplied by other blacks to coastal-living ones.

Dr. E. O. Marks demonstrated an application of the capillarity of water in the form of a new design of roof gutter which prevents the collection in it of leaves and other debris. In the gutter exhibited the rain water runs on to a curved sheet to which it clings, and is led down the inverted surface into the gutter channel. By this means the channel is situated under and protected by the curved sheet. After a year's use on a roof under a large tree the gutter is quite free from leaves and has easily carried off the heaviest rain.

Messrs. Tryon, Francis, and Buhot commented upon the exhibits.

Publications have been received from the following Institutions, Societies, etc., and are hereby gratefully acknowledged.

AFRICA.

Durban Museum, Durban.
South African Museum, Capetown, South Africa.
Transvaal Museum, Pretoria, South Africa.
Geological Society of South Africa, Johannesburg.

AMERICA.

BRAZIL—

Instituto Oswaldo Cruz, Rio Janeiro.

CANADA—

Department of Mines, Ottawa.
Royal Canadian Institute, Toronto.
Royal Astronomical Society of Canada, Toronto.
Royal Society of Canada, Ottawa.

UNITED STATES—

American Academy of Arts and Sciences, Boston.
American Geographical Society, New York.
National Academy of Science, Philadelphia,
American Philosophical Society, Philadelphia.
Californian Academy of Science, San Francisco.
Indiana Academy of Science.
Rochester Academy of Science.
National Academy of Science and Smithsonian Institute, Washington.
Library of Congress.
American Museum of Natural History, New York City.
New York Zoological Society, New York.
Department of Agriculture.
Department of Commerce, New York.
Missouri Botanic Gardens, St. Louis, Missouri.
University of California, Berkeley.
University of Colorado.
Cornell University.
John Hopkins University.
University of Illinois, Urbana.
Ohio State University.
University of Kansas, Lawrence.
University of Minnesota, Minneapolis.
Oberlin College.
National Research Council.
Buffalo Society of Natural Science.
Portland Society of Natural History.
Lloyd Library.
The University of Michigan, Michigan.
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Ohio Academy of Science.
Bureau of Standards, Washington.
Puget Sound Biological Station, University of Washington, Seattle.

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Botanic Gardens, Sydney.
Geological Survey of N.S.W., Sydney.
Public Library, Sydney.
Linnean Society of N.S.W., Sydney.
Australian Museum, Sydney.
Royal Society of New South Wales, Sydney.
Naturalists' Society of N.S.W., Sydney.
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- Royal Society of Victoria, Melbourne.
- Field Naturalists' Club, Melbourne.
- Department of Agriculture, Melbourne.
- Department of Mines, Melbourne.
- Australasian Institute of Mining and Metallurgy, Melbourne.
- Institute of Science and Industry, Melb.
- Commonwealth Department of Health, Melb.

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- Geological Survey of Tasmania.

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- Royal Geographical Society of S.A., Adel.
- National Museum of South Australia, Adel.
- Geological Survey of S. Australia, Adel.
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- Geological Survey of W. Australia, Perth.

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- New Zealand Board of Science and Art.
- Dominion Laboratory, Wellington.
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- New Zealand Institute, Wellington.
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- Société Botanique de France, Paris.
- Musée d'Histoire Naturelle, Paris
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- Office Scientifique Pêches Maritimes.
- Observations Meteorologique de Mont Blanc.

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- Gesellschaft für Erdkunde, Berlin.
- Centralblatt für Bakteriologie, Parasitenkunde und Infectionskrankheiten.
- Feddes Repertorium, Berlin.
- Botanisches Archiv, Konigsberg, Pr.

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- Literary and Philosophic Society, Manchester.
- Royal Society of London.
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- Botanic Society, Edinburgh.
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ITALY—
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